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Abstract

This paper makes use of a new dataset to investigate energy intensity developments in the Netherlands over the period 1987–2005, in comparison with 18 other OECD countries. A key feature of our analysis is that we combine this cross-country perspective with a high level of sector detail, covering 51 sectors. Particularly innovative is our evaluation of energy intensity developments in a wide range of Service sectors. We find that between 1987 and 2005 energy intensity in the Netherlands decreased on average with 0.9% points per year at the aggregate economy level and with 0.2% points at the aggregate manufacturing sector level, whereas it increased with 0.4% points at the aggregate Service sector level. This performance is considerably below the OECD average, and has been especially poor between 1987 and 1995. In terms of energy intensity levels, performance of the Netherlands is close to the OECD average at the aggregate economy level and in Manufacturing. In Services, the energy intensity level in the Netherlands was about 50% lower than the OECD average in 1987, but this lead has almost disappeared by 2005. Finally, we find that in the Manufacturing sector, between 1987 and 2005, about half of the energy efficiency improvements were undone by a shift towards a more energy-intensive industry structure, most notably through growth of the Chemical sector. In the Service sector, on the contrary, shifts in the underlying sector structure helped in slowing down energy intensity increase by about one-third between 1987 and 2005.

Keywords: Energy productivity, energy intensity, decomposition, sectoral analysis.

Abstract in Dutch

Deze studie maakt gebruik van een nieuwe dataset voor het analyseren van de ontwikkeling van energie-intensiteit in Nederland, gedurende de periode 1987–2005 en in vergelijking met 18 andere OESO-landen. Een belangrijk kenmerk van onze analyse is de combinatie van meerdere landen en een gedetailleerd sectorniveau. Bijzonder vernieuwend is een evaluatie van de ontwikkeling van de energie-intensiteit in een reeks van dienstensectoren. Uit onze analyse blijkt dat tussen 1987 en 2005 de energie-intensiteit in Nederland is afgenomen met 0.9% procent-punt voor de economie als geheel en met 0.2% procent-punt in de industrie, terwijl de energie-intensiteit met 0.4% procent-punt is gestegen in de dienstensector. Deze prestatie is aanzienlijk lager dan het OESO-gemiddelde en was vooral laag in de periode tussen 1987 en 1995. Het niveau van energie-intensiteit in Nederland komt ongeveer overeen met het OESO-gemiddelde voor de economie als geheel en voor de industrie. In de dienstensector was het niveau van energie-intensiteit ongeveer 50% lager dan het OESO-gemiddelde in 1987, maar deze voorsprong is bijna verdwenen in 2005. Ten slotte, onze analyse laat zien dat in de industrie, tussen 1987 en 2005, ongeveer de helft van de energie-efficiënte verbeteringen zijn tenietgedaan door een verschuiving naar een meer energie-intensieve sectorstructuur, vooral door de groei van de chemische industrie. In de Dienstensector, daarentegen, heeft de verschuiving in de onderliggende sectorstructuur tussen 1987 en 2005 bijgedragen aan een vertraging van de toename van de energie-intensiteit met ongeveer een derde.

Steekwoorden: Energie-Intensiteit, convergentie, decompositie, sectorale analyse

Table of contents

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1. Introduction

Like in most developed countries in the Netherlands, the efficient use of energy has been the goal of many initiatives over the past decades. Also in the next decades improving energy efficiency continues to be an important strategy to help meeting future energy needs in the context of concerns about greenhouse gas emissions and energy security. Appropriate future projections and policy design in this area require at least a careful evaluation of historic trends as regards the efficient use of energy. A natural starting point for such an evaluation is an analysis of trends in energy intensity, i.e. the ratio of energy use per unit of economic activity. This paper aims to provide such an evaluation for the Netherlands, by examining the development of energy intensity in 51 sectors of the Dutch economy during the period 1987–2005. In an era of globalization, country-specific trends should ideally be evaluated in comparison with developments in other countries – which is particularly true for a small open economy like the Netherlands. Hence, we compare Dutch energy intensity developments with those in 18 other OECD countries. The combination of this international perspective with a high level of sector detail is a key feature of this study.

More specifically, our analysis includes the following components. First, we characterize the composition of the Dutch economy in terms of sector shares in aggregate energy consumption and value added, on its own and in relation to the OECD average. Second, we document per sector the evolution of energy intensity and its components – energy use and value added – since 1987. Third, we calculate per sector annualized growth rates of energy intensity, comparing the Netherlands with the OECD average. Fourth, by means of a decomposition-analysis we calculate to what extent aggregate energy intensity trends are to be explained from, respectively, shifts in the underlying sector structure (structure effect) and efficiency improvements within individual sectors (efficiency effect). We compare Dutch aggregate growth rates of energy intensity before and after correcting for structural changes, with those in 18 other OECD countries. Moreover, for the Netherlands we examine the role of individual sectors in driving the aggregate structure and efficiency effects. Finally, we compare energy intensity levels in the Netherlands with the OECD average, thus indicating the relative performance of the Netherlands in international perspective.

Our analysis is closely related to numerous empirical studies exploring the development and determinants of energy intensity, energy productivity, or energy efficiency (see, for example, Berndt 1978, Fisher-Vanden 2004, IEA 2004, Miketa 2001, Mulder and De Groot 2003; 2007, Nilsson 1993, De Nooij et al. 2003, Worell 2004, Schipper and Meyers 1992, Sue Wing 2008). Evidently, our focus on the Netherlands implies a particular resemblance to those studies in this area that have investigated energy efficiency developments in various sectors of the Dutch economy (see, for example, Boonekamp 1998, Boonekamp et al. 2002, Farla and Blok 2002, Gerdes et al. 2009, Neelis et al. 2007, Ramírez et al. 2005, 2006). Many of these studies decompose changes in aggregate energy intensity into a structure effect and an efficiency effect. This is done by means of what is known as index number decomposition, a methodology that goes back to Fisher (1922), Siegel (1945) and Shapley (1953) and has since long been applied by researchers studying changes in total factor productivity or labour productivity (see, for example, Maddison 1952, Massell 1961, Dollar and Wolff 1993, Van Ark 1996 and Fagerberg 2000). Since the late 1970s this methodology has been widely used and further developed in the field of energy studies to decompose aggregate changes in energy use, energy intensity, or emission intensity (see Ang and Zhang 2000 and Liu and Ang 2007 for reviews). In this paper we make use of the most recent insights from this literature to decompose changes in energy intensity in a structure effect and an efficiency effect, comparing the Netherlands with 18 OECD countries.

Our analysis makes use of a new and unique dataset that is distinctive in terms of quality and coverage. The heart of this dataset is formed by the recently developed 'EU KLEMS Growth and Productivity Accounts' database, which we link to physical energy data from the International Energy Agency (IEA). The explicit link to physical energy data from the International Energy Agency (IEA) allows us to compare EU KLEMS based figures on energy use and energy intensity with the widely used IEA based figures. The EU KLEMS database includes information on both output and energy input derived from a consistent framework of national accounts and supply-and-use tables and processed according to agreed procedures. This is in contrast to most of the aforementioned studies – in particular those that include a cross-country perspective – that rely on study-specific *ad hoc* combinations of energy input and economic output measures from different sources to analyze trends in energy productivity or energy intensity. Often, this hampers replication and international comparison of country-specific results. Another major advantage of the EU KLEMS database is that it moves beneath the aggregate economy level by providing a breakdown of industries to a common detailed level. Typically, cross-country studies of productivity and growth come at the price of limited sectoral detail. This is a serious drawback, given the existence of substantial heterogeneity in output and productivity growth across industries (see, for example, Bernard and Jones 1996; Dollar and Wolff 1993). Also in the area of energy studies, it has been shown that aggregate trends of energy intensity (productivity) mask considerable differences across industries (see, for example, Huntington 2010, Jorgenson 1984, Miketa and Mulder, 2005, Mulder and De Groot 2003). The high level of sector detail in the EU KLEMS database allows for examination of productivity performance of individual industries and their contribution to aggregate growth.

Our analysis includes an internationally comparable assessment of 25 Manufacturing sectors (10 main sectors, 15 sub sectors), 23 Service sectors (9 main sectors, 14 sub sectors), as well as the sectors Transport, Agriculture and Construction. Particularly innovative is our evaluation of energy intensity developments in a wide range of service sectors. Most empirical energy studies focus on the Manufacturing sector, due to its large share in aggregate final energy consumption and the (consequently) relative readily available data. However, in high-income countries, like the Netherlands, the service sector accounts for a majority share of GDP while its share in total final energy consumption is increasing steadily. Because of limited data availability, those studies that do include a more detailed assessment of energy demand in the service sector are predominantly country-specific, impeding international comparability (see, for example, Florax et al. 2011, Huntington 2009, Mairet and Decellas 2009, Ramírez et al. 2002). In contrast, our evaluation of energy demand in the Dutch service sector offers an international perspective.

The structure of the paper is as follows. In Section 2 we describe in more detail our data. In Section 3 we explain briefly the index number decomposition methodology we apply in our analysis. In Section 4 we present the results of the various elements of our analysis for the aggregate economy level, distinguishing the aggregate sectors Manufacturing, Services, Transport, Agriculture and Construction. In Section 5 we take a closer look at the Manufacturing sector, identifying the role of 25 individual Manufacturing sectors. In Section 6 we repeat this analysis for the Services sector, including an assessment of 23 individual Service sectors. Section 7 concludes.

2. Data

The dataset we use and present in this study combines the recently launched EU KLEMS database with energy data from the International Energy Agency (IEA). Primary objective of the EU KLEMS database is to support empirical and theoretical research in the area of economic growth, studying patterns of productivity and its principal determinants such as skill formation, technological progress and innovation (O'Mahony and Timmer 2009). The database includes measures of output and input growth as well as derived variables such as multi-factor productivity, organized around the growth accounting methodology rooted in neoclassical production theory. However, the data collected are also useful in other contexts, as the EU KLEMS database provides many basic input data that are derived independently from the assumptions underlying the growth-accounting method. They include various categories of capital, labour, energy and material. The database has been constructed on the basis of data delivered by EU KLEMS consortium partners with cooperation of national statistical offices, and processed according to agreed procedures. The approach taken is a two-step procedure. First, the most recent and revised series by industry on gross output, value added and total intermediate inputs were taken from National Accounts. These series are extended and broken down into more industry-detail if needed. In a second step total intermediate inputs were broken down into energy, materials and services based on supply-and-use tables.[1]

We measure energy intensity by the ratio of intermediate energy input to gross value added – thus being the inverse of energy productivity. Value added data have been converted to constant 1997 US$, using a new and comprehensive dataset of industry-specific Purchasing Power Parities (PPPs) for 1997. These PPP series were constructed in the EU KLEMS project by double deflation of gross output and intermediate inputs within a consistent input-output framework. The price concepts for gross output (basic prices) and intermediate inputs (purchasers' prices) have been harmonized across countries. As these series are often short (as revisions are not always taken back in time) different vintages of the National Accounts were bridged according to a common link-methodology (O'Mahony and Timmer 2009). Depending on country and sector, these value added series can differ from those available in the STAN database, even though STAN is also based on National Account series. Two issues explain the differences. First, STAN makes use of aggregate country-specific PPPs, whereas in EU KLEMS PPP's have been constructed at the industry-level – a major step forward. Second, in harmonizing long-term nominal and price series for output and intermediate inputs STAN and EU KLEMS employ different vintages of National Accounts as well as different sector classifications.

The EU KLEMS energy data that we employ are also derived from a harmonized system of National Accounts. They consist of expenditure based intermediate inputs that encompass all energy mining products, oil refining products and electricity and gas products. Using detailed supply-and-use tables, energy expenditures at the industry-level have been deflated by the relative price index of each fuel (energy carrier). As mentioned before, this implies that the intermediate energy input series and value added series are mutually consistent. Hence, to construct a value added based energy intensity indicator one no longer needs to rely on different sources, with its inherent complications. However, somewhat unfortunately the intermediate energy data series in EU KLEMS are provided in

[1] We use the EU KLEMS March 2008 release. For a more detailed description and discussion of the EU KLEMs database, we refer to (O'Mahony and Timmer 2009). In addition, methodological background papers are available at the EU KLEMS website (www.euklems.net). The EU KLEMS data series are also publicly available at this website.

terms of volume indices only. Consequently, unlike energy intensity growth rates the original EU KLEMS database does not allow exploring energy input *levels* across countries and across sectors. For this reason we enriched the EU KLEMS database by establishing a link with physical energy data from the IEA, according to the following simple two-step procedure. First, for the year 2005 we matched the EU KLEMS energy volume index number with IEA final energy consumption data in kilo tonnes of oil equivalent (ktoe). Second, we used the EU KLEMS energy input volume indices to (re)calculate energy consumption in ktoe back in time. Guided by the sectoral classification that the IEA uses in its Energy Balances, the first step could be done straightforwardly for 10 Manufacturing sectors as well as the aggregate Service, Transport, Agriculture and Construction sectors. For the remaining sub-sectors, we applied proportions of sub-sectoral intermediate energy input expenditures (at purchasers' prices), as given in EU KLEMS, to IEA final energy consumption data at the aggregate sector level, again for the year 2005. This procedure rests on the assumption that in 2005 *within* a specific industry average energy prices are identical across sub-sectors. This would require the same fuel price levels as well as the same fuel mix across sub sectors within an industry. This requirement is met in all Service sectors (almost exclusively consuming electricity) as well as in most Manufacturing sectors, except for the aggregate sector Non-Specified Industry (see Table 2.1). Hence, our figures for this industry require careful interpretation as – depending on the country – they might suffer from some degree of bias, predominantly due to differences in fuel mix across its sub sectors. In general, it has to be borne in mind that our data do not allow to account for the role of fuel input mix in driving aggregate energy intensity developments since the EU KLEMS database only provides volume indices of aggregate intermediate energy inputs, defined as an expenditure based aggregate of all energy carriers.

It is to be noted that, except for 2005, physical energy consumption series in our dataset – which are ultimately based on EU KLEMS energy input volume indices – can deviate from final energy consumption series reported by the IEA. Differences between the two sources arise from two methodological issues. First, for the most part IEA energy consumption data are based on 'mini questionnaires' received from national administrations of OECD countries as well as on monthly oil questionnaires, whereas within the EU KLEMS framework energy is defined as an intermediate input that is derived from national accounts and supply-and-use tables.[2] Second, the EU KLEMS intermediate energy input series include energy used for transformation and own use, whereas this is excluded from IEA final energy consumption data. For most sectors, only a (very) small part of intermediate energy input reflects energy used for transformation and own use. However, the picture might be different in those sectors that make use of large-scale cogeneration of heat and power (CHP) and/or are characterized by a relatively large amount of non-energy use, i.e. fuels that are used as raw materials (feedstock). Regarding CHP, the IEA and EU KLEMS definitions are identical insofar end-use sectors consume fuel to produce heat and power for own use. But when an end-use sector consumes fuel to produce heat and power for sale to other sectors and/or the general grid the two databases differ: in the IEA statistical system this fuel is included in the transformation sector whereas EU KLEMS includes these fuels in the concerning end-use sector. In the Netherlands, this is especially an issue in the Agricultural sector, which is dominated by the horticulture industry with a large installed CHP capacity (about 500MW) that over the past decade increasingly sold electricity (Van der Velden and Smit 2008). Hence, this should be kept in mind when interpreting

[2] It is to be noted that in most cases intermediate energy inputs as reported in the use tables are derived from production statistics, and thus not necessarily correspond with energy data reported in surveys. However, for the Netherlands energy data from both sources have been harmonised.

the energy intensity indicators reported in this study, particularly when compared to other studies. The issue of non-energy (feedstock) use plays an important role in the Chemical sector, with the Petrochemical industry consuming large quantities of fuel as feedstock.

As mentioned before, a key feature of the EU KLEMS database is its high level of sector-detail. At the lowest level of aggregation, the EU KLEMS database includes 71 sectors, classified according to the European NACE revision 1 classification. However, due to data limitations the level of detail varies across countries, industries and variables. Obviously, in our case the energy input measure is a key variable and as a result of limitations in its availability our dataset distinguishes 51 sectors in order to ensure international comparability of the data. Table 2.1 provides a list of the sectors, including higher aggregates. This industry division is more detailed than the 2-digit level that has been used so far in most cross-country energy intensity analyses. Consequently, our dataset makes it possible to move further beneath the aggregate economy level when analyzing energy intensity developments across countries. Nevertheless, when using this data in the field of energy economics four caveats are to be borne in mind. First, the Chemicals sector combines the energy-intensive sub-sector Basic Industrial Chemicals and the energy-extensive sub-sector Pharmaceuticals. Although EU KLEMS provides here a breakdown at the lowest level of aggregation, limited data availability allowed us to only include the 2-digit industry level in order to secure comparison across countries. Second, the Basic Metals sector is an aggregate of the sub sector Non-Ferrous Metals and the sub-sector Iron and Steel. Here, EU KLEMS does not provide a further breakdown – making it the only sector with less industry detail than previously available (for example, by combining STAN and IEA data or in the dataset developed by Mulder and De Groot 2003, 2007). Third, energy consumption in the IEA Transport sector covers all transport activity (in mobile engines) – including aviation, road, rail and domestic navigation – regardless of the economic sector to which it is contributing. It also includes household demand for transport fuels while for many countries the domestic/international split in aviation fuel data incorrectly excludes fuel used by domestically owned carriers for their international departures. Value added data in our Transport sector refer to carrier (commercial) transportation and do not include personal transportation, since the latter is not part of National Accounts. Hence, energy intensity indicators for the Transport sector should be interpreted with caution. Fourth, the focus of EU KLEMS on productive sectors precludes the analysis of households and the personal transport sector, since they predominantly involve non market activities that are excluded from National Accounts. In short, our dataset deals with non-residential energy use. This is important to keep in mind, particularly because in some countries (especially the USA) personal transportation is a substantial factor in explaining aggregate energy consumption. Finally, our dataset does not include energy production or transformation sectors.

Table 2.1 Sector classification

Sector	NACE rev1 code
MANUFACTURING	**15t22, 24t37**
FOOD, BEVERAGES AND TOBACCO	15t16
Food and beverages	15
Tobacco	16
TEXTILES, LEATHER AND FOOTWEAR	17t19
Textiles	17t18
Leather and footwear	19
WOOD AND CORK	20
PULP, PAPER, PRINTING AND PUBLISHING	21t22
Pulp and paper	21
Printing, publishing and reproduction	22
CHEMICALS	24
NON-METALLIC MINERALS	26
BASIC METALS	27
MACHINERY	28t32
Fabricated metal	28
Machinery not elsewhere classified (n.e.c.)	29
Office, accounting and computing machinery	30
Electrical engineering	31t32
TRANSPORT EQUIPMENT	34t35
Motor vehicles, trailers and semi-trailers	34
Other transport equipment	35
NON-SPECIFIED INDUSTRY	25,33,36t37
Rubber and plastics	25
Medical, precision and optical instruments	33
Manufacturing not elsewhere classified (n.e.c.); recycling	36t37
SERVICES	**GtH, J, LtO, 64, 71t74**
WHOLESALE AND RETAIL TRADE	G
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	50
Wholesale trade and commission trade, except of motor vehicles and motorcycles	51
Retail trade, except of motor vehicles and motorcycles; repair of household goods	52
HOTELS AND RESTAURANTS	H
POST AND TELECOMMUNICATIONS	64
FINANCIAL INTERMEDIATION	J
Financial intermediation, except insurance and pension funding	65
Insurance and pension funding, except compulsory social security	66
Activities related to financial intermediation	67
RENTING, COMPUTER, R&D and OTHER BUSINESS	71t74
Renting of machinery and equipment	71
Computer and related activities	72
Research and development	73
Other business activities	74
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECURITY	L
EDUCATION	M
HEALTH AND SOCIAL WORK	N
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	O
Sewage and refuse disposal, sanitation and similar activities	90
Activities of membership organizations n.e.c.	91
Recreational, cultural and sporting activities	92
Other service activities	93
TRANSPORT	**60t62**
AGRICULTURE, HUNTING, FORESTRY AND FISHING	**AtB**
CONSTRUCTION	**F**

Finally, our dataset includes the following countries: 12 EU-15 countries (Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom), 4 new EU member states (Czech Republic, Hungary, Poland, Slovakia), the USA, Japan and South Korea.[3] In general, for the EU-15 countries, the USA and Japan data are available for the period 1970–2005, whereas for the new EU member states series are available from 1995 onwards. Exceptions include France and Germany for which data are available from 1978 onwards; Austria, Belgium and Japan for which data are available from 1980 onwards; and the Netherlands and Sweden for which data are available as from 1987 and 1993, respectively. Given our focus on the Netherlands, this study covers the period 1987–2005. In our analysis we often distinguish the period 1987–1995 (14 countries) from the period 1995–2005 (19 countries). For a more detailed description of the data we refer to O'Mahony and Timmer (2009). Mulder and De Groot (2011) provide a systematic analysis of energy intensity developments across 19 OECD countries, employing the same database as we use in this paper.

[3] The original EU KLEMS database also includes Australia, Cyprus, Estonia, Greece, Ireland, Latvia, Lithuania, Luxembourg, Malta and Slovenia. Limited data availability made us decide to not include these countries in the final dataset.

3. Decomposition approach

Changes in energy intensity at the aggregate economy level result not only from technology-driven efficiency improvements in individual sectors, but also from changes in the sector composition of the economy. The latter is caused by the fact that sectors differ inherently in terms of their requirement of energy inputs relative to other inputs like capital and (skilled) labour. By using index number decomposition (or shift-share) analysis, we are able to decompose changes in aggregate energy intensity into a so-called structure effect and an efficiency effect. The structure effect measures the change in the economy's energy intensity due to the changing composition of activities within the economy. The efficiency effect, in contrast, measures changes due to efficiency improvements within each sector. In the field of energy studies this methodology has been widely used to decompose aggregate changes in energy use, energy intensity, or emission intensity (see Ang and Zhang 2000 and Liu and Ang 2007 for reviews).

To describe the essence of index number decomposition methodology algebraically, let i denote the sectors of the economy and let Y and E represent output (value added) and energy consumption. Aggregate energy intensity I, defined as the ratio of energy to output, can then be calculated as:

$$I = \frac{E}{Y} = \sum_i \frac{E_i}{Y_i}\frac{Y_i}{Y} = \sum_i I_i S_i \tag{1}$$

In this equation, I_i represents the within-sector intensity; S_i is the share of the sector in total value added. The efficiency effect is derived by controlling aggregate energy intensity for adjustments in the economy's structure. In other words, the efficiency effect equals the isolated within-sector intensity effect, which is (supposedly) largely driven by technological improvements. Since both the structure effect and the efficiency effect change over time, it is necessary to establish appropriate weights in order to measure the contribution of each effect. Decomposition analysis in the field of energy studies have used a variety of weights, which translates into a range of applied decomposition approaches (see Ang et al. 2003, Ang 2004, Ang et al. 2004, Boyd and Roop 2004, and Zhang and Ang 2001, for reviews and details). In this study we use the so-called log mean Divisia index method (LMDI I) as introduced by Ang and Liu (2001), which in its additive form decomposes a change in aggregate energy intensity (ΔI_{tot}) between period 0 and T into an efficiency effect (ΔI_{eff}) and a structure effect (ΔI_{str}) according to:

$$\Delta I_{eff} = \sum_i w_i \ln\left(\frac{I_i^T}{I_i^0}\right) \tag{2}$$

$$\Delta I_{str} = \sum_i w_i \ln\left(\frac{S_i^T}{S_i^0}\right) \tag{3}$$

where w_i is the weighting function defined as $w_i = L(V_i^T, V_i^0)$, with $V_i = \sum_i I_i S_i$ and L the logarithmic average of two positive numbers a and b given by $L(a, b) = (a–b) / \ln(a / b)$. [4]

The choice for this approach is primarily motivated by its ability to satisfy the factor-reversal test, i.e. it provides perfect decomposition results without a residual. Moreover, this approach can handle zero values effectively, the results are invariant to scaling and it satisfies the time-reversal test, i.e. estimated values between period 0 and T and

[4] A simple relationship exists between the additive and multiplicative form, which thus can be easily related to each other.

period T and 0 are equal (in absolute terms). In the two-factor case, this approach is equivalent to the Fisher ideal index method that is defined as the square root of the product (i.e. geometric average) of the Laspeyres and Paasche indices (Ang 2004, Boyd and Roop 2004).[5] For the aforementioned reasons the LMDI and Fisher ideal index methods have emerged as the preferred methods in energy index decomposition analysis (Ang 2004).

By definition, decomposition of energy intensity requires combining energy data with indicators that measure output or activity. The latter can be expressed either in terms of engineering or physical indicators – like metric tonnes, kilometers or square meters of floor space – or in terms of economic indicators – such as value added or gross output. Examples of decomposition analysis using physical indicators can be found in Farla and Blok (2000), Neelis et al. (2007), Ramírez et al. (2006a, b), Worell et al. (1997) – all focusing on energy intensity developments in the Netherlands. The main advantage of using a physical indicator is that it often establishes a straightforward relationship between output and energy inputs, irrespective of changes in the mix and characteristics of products and feedstock and changes in market-based product prices. However, its application is hindered by difficulties of aggregation across sectors and limited data availability, which of course is particularly true in sectors with a large variety of products and a large degree of processing, as well as in a cross-country setting. In contrast, an economic indicator such as value added facilitates comparison of energy intensity across countries and across sectors, as well as interpretation within an economic framework that includes other inputs like capital and labour. For these reasons we have chosen in this study to express activity levels in economic terms, using value added as our measure.

Finally, apart from method and type of indicators, a more important factor that influences decomposition results is the level of sectoral detail that is used. The more sectoral detail is included in the decomposition exercise, the more the calculated efficiency effect represents a technology-driven efficiency improvement. With less degree of sector detail, the calculated efficiency effect becomes less precise because it increasingly includes changes in the activity- or product mix *within* the sector, thus including what essentially are disaggregated sector effects. As noted before, our dataset enables the inclusion of a level of sector detail that is relatively high in comparison to existing energy decomposition analyses, especially those that exhibit a cross-country perspective (Liu and Ang 2007). Consequently, the efficiency effects that we report in this study are a relatively accurate approximation of technology-driven efficiency improvements. Yet it is appropriate to mention one caveat here. Since the EU KLEMS database provides volume indices of aggregate intermediate energy inputs only (including all energy mining products, oil refining products and electricity and gas products), we are not able to correct our efficiency effect for changes in the fuel input mix. The latter might have an impact because energy carriers (natural gas, electricity, coal, etc.) differ in terms of available energy, i.e. they differ in terms of quality or efficiency in delivering energy services (Berndt 1978, Cleveland et al. 2000).

[5] The generalized Fisher approach has its roots in studies by Siegel (1945) and Shapley (1953); see De Boer (2008).

4. Aggregate economy level

In this section, we analyze the development of energy intensity in the Netherlands at the aggregate economy level (Macro), defined as the sum of the sectors Manufacturing, Services, Transport, Agriculture and Construction.[6] By way of introduction we present in Figure 4.1 for the Netherlands the shares of these five main sectors in aggregate energy consumption and aggregate value added, for the year 2005.

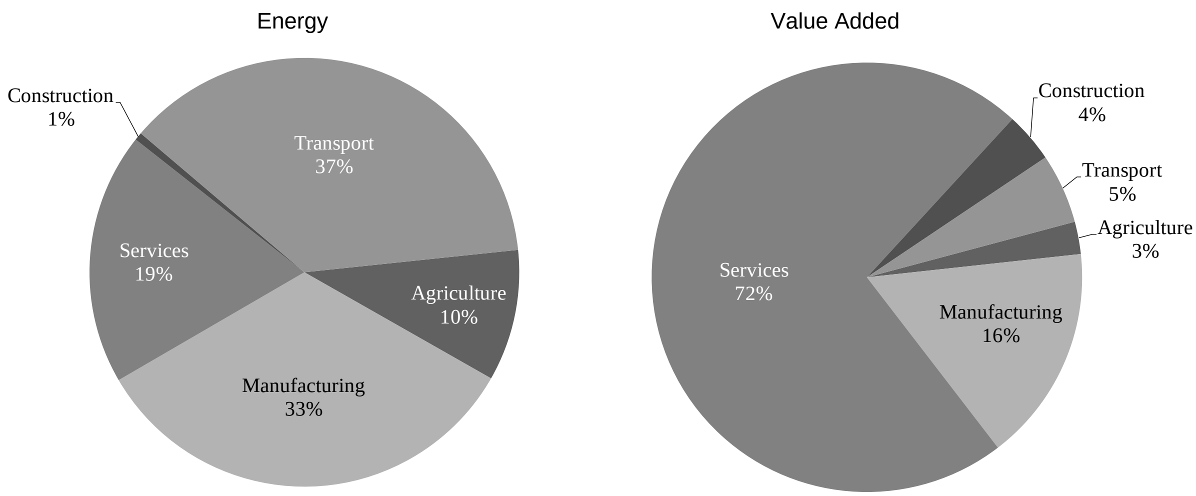


Figure 4.1. Percentage sector shares of aggregate energy consumption and value added in the Netherlands, 2005.

From the Figure it can be seen that with 72% the Service sector accounts for a major share of aggregate value added, whereas most energy is consumed in Transport and Manufacturing – with a respective share of 37% and 33% of aggregate energy use. Of the remaining 30% of aggregate energy use, Services accounts for 19%, followed by Agriculture with 10% and Construction with 1%. Of the remaining 28% of aggregate value added, 19% is created by Manufacturing, while Transport, Construction and Agriculture account for 5%, 4% and 3%, respectively. Hence, particularly for Transport and Services a large contrast exists between their shares of aggregate energy consumption and shares of total value added, with Transport being energy-intensive and Services energy-extensive. The shares shown in Figure 4.1 have been fairly constant since 1987, except for a considerable increase of the Services share in aggregate energy consumption (which increased from 15% in 1987 to 19% in 2005).

In Figure 4.2 we compare these shares with the average OECD shares.[7] Values are indexed, relative to the OECD average as denoted by the axes (OECD = 1.0). The Figure shows that in the Netherlands Agriculture and particularly Transport are relatively large sectors in terms of value added, whereas the opposite is true for the Manufacturing and Construction sectors. The value added share of Service sector is just above the OECD average.

[6] Note that by implication energy consumption of households is not included in our analysis.

[7] Unless otherwise stated, in this paper OECD is defined to encompass the following group of 14 countries: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Japan, Korea, The Netherlands, Portugal, Spain, United Kingdom and United States. The OECD average is defined as a weighted average, calculated by means of the sum of the aforementioned 14 countries.

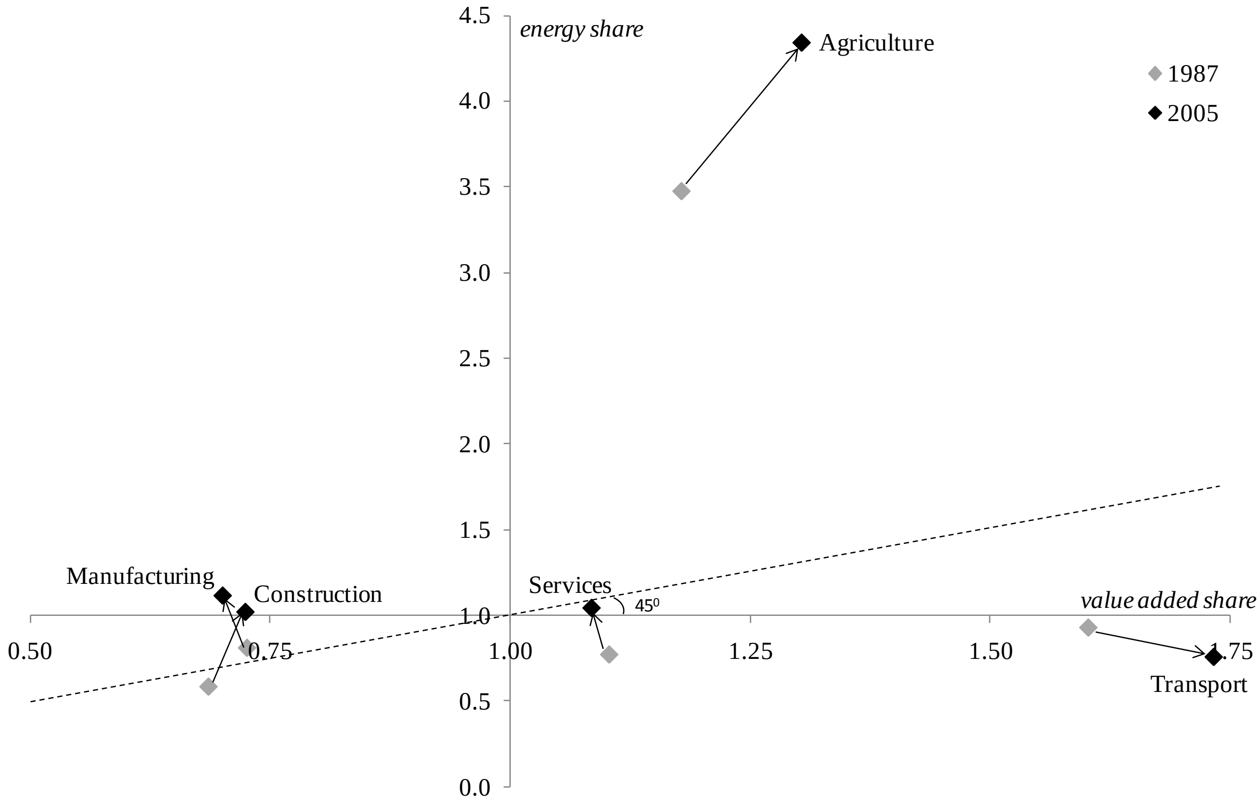


Figure 4.2 Sectoral value added and energy shares in the Netherlands as compared to the OECD average and its dynamics over time (OECD = 1.0)

Points on the dashed diagonal line are points where the sectoral energy intensity is the same as the aggregate OECD average. Sectors to the Northwest are relatively energy intensive, whereas sectors to the South East are energy extensive. From the Figure it can be seen that energy intensity in the Dutch Manufacturing and Construction sectors is very similar to the OECD average, albeit slowly increasing, whereas in the Transport sector it is increasingly lower than the OECD average. Most notably, however, is that the Netherlands has a highly energy intensive Agricultural sector relative to the OECD average. This is obviously due to the fact that the Dutch agricultural sector is characterized by a large horticultural sub sector – about 80% of energy use in the Agricultural sector in the Netherlands is caused by greenhouses for vegetables and flowers (Needis 1995) – that in terms of energy intensity is comparable to basic metals and basic chemicals (Boonekamp et al. 2002).

To gain more insight in the development of energy intensity over time, we present in Table 4.1 for three different time periods the average annual growth rate of energy intensity and its components: energy use and value added. We do so for the aggregate economy level as well as individual main sectors. To facilitate comparison and interpretation of our data, we also provide the average annual growth rates of, respectively, energy use according to IEA data, value added according to STAN data, as well as energy intensity according to the combination of these two data sources.

Table 4.1 Change in energy use, value added and energy intensity

Average annual growth rates	Energy Intensity						Energy Use						Value Added					
	1987−2005		1987−1995		1995−2005		1987−2005		1987−1995		1995−2005		1987−2005		1987−1995		1995−2005	
	EUK	IEA/ STAN	EUK	IEA/ STAN	EUK	IEA/ STAN	EUK	IEA	EUK	IEA	EUK	IEA	EUK	STAN	EUK	STAN	EUK	STAN
Macro	–0.9	–1.3	1.5	–1.7	–2.8	–1.1	1.7	1.2	3.9	0.8	–0.1	1.5	2.6	2.6	2.4	2.5	2.7	2.6
Macro*	–0.4	–0.7	1.4	0.0	–1.7	–1.4	2.3	2.0	3.8	2.7	1.1	1.4	2.6	2.7	2.4	2.6	2.8	2.8
Manufacturing	–0.2	–1.5	1.1	–3.7	–1.3	0.2	2.1	0.6	3.8	–1.2	0.8	2.1	2.3	2.2	2.6	2.6	2.1	1.8
Services	0.4	3.2	2.7	9.5	–1.4	–1.5	3.1	6.2	5.1	12.3	1.6	1.5	2.7	2.9	2.3	2.6	3.1	3.1
Transport	–2.3	0.0	0.4	0.5	–4.5	–0.4	0.8	2.7	4.1	3.6	–1.8	2.0	3.2	2.7	3.6	3.0	2.8	2.5
Agriculture	–1.1	–0.8	–2.4	0.5	–0.1	–1.9	1.4	1.7	2.0	4.9	1.0	–0.8	2.5	2.5	4.4	4.4	1.1	1.1
Construction	2.8	–0.5	6.2	1.4	0.2	–2.0	3.8	0.4	7.7	2.7	0.8	–1.4	0.9	0.9	1.2	1.2	0.6	0.6

Macro* = Agriculture + Manufacturing + Services

The Table shows that at the aggregate economy level, between 1987 and 2005, energy intensity in the Netherlands decreased with an average 0.9% per year. The first column of the Table shows that this decrease largely results from a fall in energy intensity in the sectors Transport (–2.3% per year) and Agriculture (–1.1% per year). In Manufacturing, energy intensity decreased on average with only 0.2% per year during this period. In contrast, energy intensity increased on average per year with 0.4% in the Services sector and with 2.8% in the Construction sector. The third and fifth column of Table 4.1 show that these trends have been irregular over time. Most remarkably, between 1987 and 1995, aggregate energy intensity levels increased considerably (1.5% per year), which was driven by increasing energy intensity levels in all sectors except Agriculture – that realized most of its decreasing energy intensity since 1987 in just this period. After 1995, aggregate energy intensity fell considerably (–2.8% per year), driven by developments in the sectors Manufacturing (–1.3% per year), Services (–1.4% per year) and especially Transport (–4.5% per year).

The large decrease in energy intensity in the Transport sector is difficult to interpret for two reasons. First, to a large extent it results from a remarkable average 1.8% annual decrease in energy use between 1995 and 2005 (see the eleventh column in the Table). Underlying data show this to be caused by a 2001 series break in the sub sector Other Inland Transport (NACErev1 code 60) that is not reflected in IEA data and that cannot be well explained otherwise. Second, as argued in Section 2, the IEA classification incorporated in our dataset implies substantial heterogeneity in Transport energy data, covering all transport modes regardless of the economic sector to which it is contributing, including households. For these reasons we redefine the aggregate economy level such that it only covers the three traditional main sectors Agriculture, Manufacturing and Services. Table 4.1 shows that according to this definition – which we label Macro* – energy intensity in the Netherlands decreased on average with only 0.4% per year between 1987 and 2005 (first column). This result is the product of a 1.4% annual increase in total energy intensity between 1987 and 1995 (third column) followed by a 1.7% average annual decrease after 1995 (fifth column). The latter result is relatively high as compared to the findings of Gerdes et al. (2009) who report annual energy saving of 1% for the Netherlands during the period 1995–2005.

A comparison with energy intensity figures based on IEA reveals that at the aggregate economy level (Macro*) they compare relatively well with to EU KLEMS based energy intensity figures, except for the period 1987–1995. Also, at the sector level substantial differences exist between figures from the two sources. Most importantly, IEA data indicate a 1.2% average annual decrease in Manufacturing energy use during the period 1987 and 1995 (tenth column) whereas EU KLEMS data indicate a 3.8% average annual increase (ninth column). Consequently, energy intensity decrease in Manufacturing is considerably larger according to IEA data than to EU KLEMS data, both for the period 1987 until 1995 (–3.7% vs. 1% per year) as well as the whole period 1987 until 2005 (–1.5% vs. –0.2% per year). After 1995, the opposite is true, with IEA data indicating a relatively high growth in energy use (2.1% vs. 0.8%) and subsequently a modest increase in energy intensity (0.2% per year) that contrasts with a 1.3% average annual decrease according to EU KLEMS data. These differences within Manufacturing are likely due to the fact that non-energy use of fuel is included in EU KLEMS intermediate energy inputs but excluded from IEA final energy consumption data. As argued in section 2, particularly in the (Petro-) Chemical industry this might cause substantial divergence between the two data sources. We return to this issue in the next section.

In addition, the other sectors also reveal considerable differences between IEA and EU KLEMS based data on energy use, implying differences in energy intensity figures. Regarding the Service sector, IEA data reveal a much higher increase in energy use between 1987 and 1995 than EU KLEMS (12.3% vs. 5.1% per year), meaning a much higher increase in energy intensity in both this period (9.5% vs. 2.7% per year) as well as the whole period 1987 until 2005 (3.2% vs. 0.4% per year). We do not have a compelling explanation for this difference. As regards Agriculture, figures on total energy intensity changes between 1987 and 2005 based on IEA and EU KLEMS are very similar (–0.8% vs. –1.1%). However, the two sources report opposite trends regarding the development of energy intensity over time: as noted before, according to EU KLEMS data energy intensity decreased substantially between 1987 and 1995 and remained more or less constant afterward, whereas according to IEA data the opposite is true. The latter results from the fact that IEA data report a 4.9% average annual increase in energy consumption in the period 1987–1995 (vs. 2% by EU KLEMS), and a remarkable 0.8% average annual decrease in energy use during the period 1995–2005 (vs. a 1.0% average annual increase by EU KLEMS). As argued in Section 2, this difference is at least partly due to the fact that the Dutch Agricultural sector is dominated by horticulture, which has a large installed CHP capacity that increasingly sold electricity over the past decade. Within the EU KLEMS framework, energy use by the Agricultural sector includes fuels used by horticulture to produce heat and power that is subsequently sold to other sectors and/or the general grid, whereas the IEA statistical system classifies this fuel use within the transformation sector. Nevertheless, the 0.8% average annual decrease in Agricultural energy use that IEA reports for the period 1995–2005 is difficult to interpret and contradicts, for example, the findings of Boonekamp (1998) and Boonekamp et al. (2002) who, similar to EU KLEMS, report increasing energy use in the Dutch Agriculture sector. Moreover, they conclude that since 1987 the heat-intensity (MJ/output) decreases somewhat, but that electricity-intensity (kWh/output) increases substantially as a result of so-called assimilation lighting, among others.

Finally, also in the Construction and Transport sector there are substantial differences between figures based on EU KLEMS data and those based IEA data. As regards the Construction sector, IEA data report a much smaller increase in energy use in the period 1987–1995 (2.7% vs. 7.7% per year), and even a 1.4% average annual decrease in energy use during the period 1995–2005 (compared to a 0.8% average annual increase by EU KLEMS). Consequently, according to IEA data energy intensity in the Construction sector decreased in the period 1995–2005 with 0.5% per year whereas EU KLEMS data indicate an average annual increase of 2.9% over the same years. We do not have a compelling explanation for this difference. Regarding the Transport sector, as noted before, IEA data do not resemble EU KLEMS in reporting a remarkable 1.8% average annual decrease in energy use between 1995 and 2005, but instead report a 2% average annual increase during this period (see the eleventh and twelfth column in Table 4.1). As a result, according to IEA data energy intensity in the Transport sector remained constant in this period whereas it decreased on average with 2.3% per year according to EU KLEMS data. As argued before, this difference is caused by a 2001 series break in the sub sector Other Inland Transport (NACErev1 code 60) that is not reflected in IEA data and that cannot be well explained otherwise.

We continue our descriptive analysis by taking a closer look at the development of energy intensity *levels* over time. In Figure 4.3 we show this development (index: 1987=100) for the aggregate economy level (Macro and Macro*), as well as the sectors Manufacturing, Services, Transport, Agriculture and Construction.

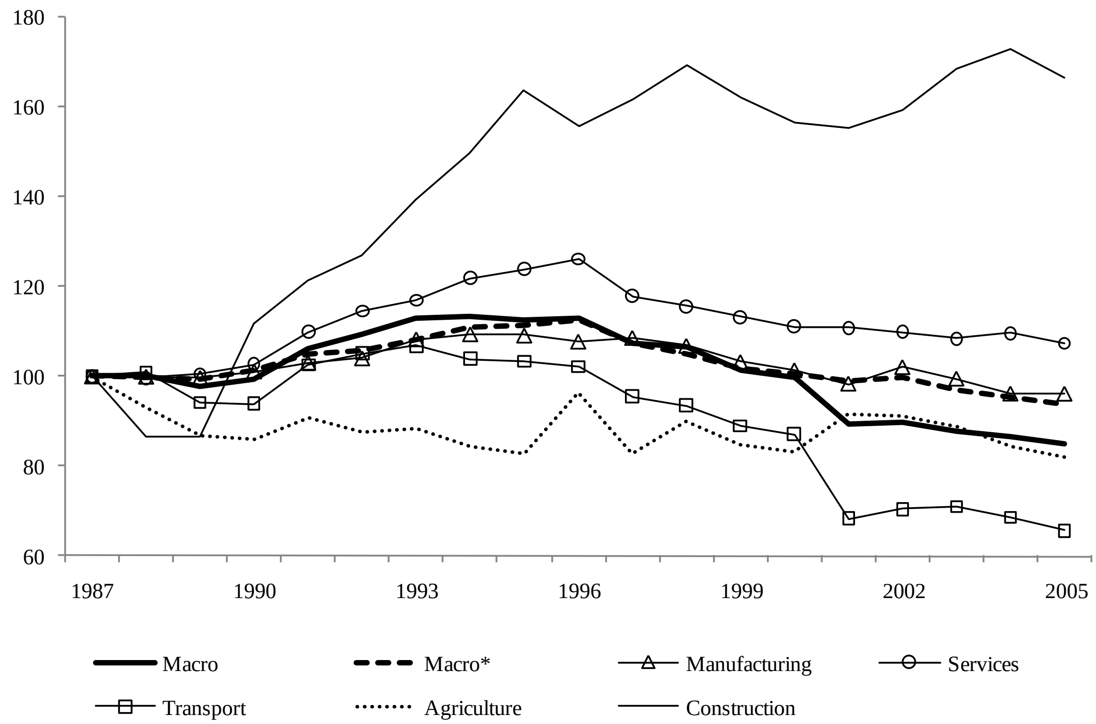


Figure 4.3 Evolution of energy intensity (index, 1987=100)

Figure 4.3 clearly shows that in general energy intensity levels increased between 1989 and 1996, and decreased afterwards. Exceptions can be found in Agriculture and Construction. In the Agricultural sector, energy intensity increased between 1987 and 1995, to remain more or less constant afterwards. The Construction sector displays a rapid increase in energy intensity between 1989 and 1998, and a subsequent stabilization at a high level. Due to a relatively large decreases in energy intensity after 1995, the energy intensity levels in 2005 are lower than in 1987 at the aggregate economy level as well as in Transport, Agriculture and Manufacturing, albeit total energy intensity decline has been very limited in the Manufacturing sector. In the Service and Construction sectors energy intensity levels are higher in 2005 as compared to 1987.

To put these trends in an international perspective, we provide in Table 4.2 the annualized growth rates of energy intensity in the Netherlands as compared to the OECD average, again for the aggregate economy level and the sectors Manufacturing, Services, Transport, Agriculture and Construction. Table 4.2 shows that, measured over the entire period 1987–2005, at the aggregate economy level (Macro) the reduction in energy intensity equals the OECD average. This result averages out a considerably poorer performance than the OECD before 1995 and a somewhat better performance after 1995. Also as compared to EU-12 and EU-4 averages, performance in the Netherlands is relatively good after 1995. However, if we exclude the Transport and Construction sector the picture is rather different. In this case (Macro*), the annualized energy intensity growth rate in the Netherlands between 1987 and 2005 is substantially below the OECD average in all periods. For the period 1995–2005 at the aggregate economy level (Macro*) the reduction in energy intensity equals the EU-12 average, but is considerably lower than the EU-4 average. At the sector level, the Netherlands performs below the OECD average in all sectors and time periods, except in Transport (cf. the aforementioned caveat) as well as in Agriculture during the period 1987–1995. Also in comparison with EU averages the Netherlands performs relatively poor, except again in Transport and to a lesser extent also in Services. It is to be noted that we might underestimate growth in energy intensity improvements in the Agricultural sector in so far (horticulture) firms consume energy for co-generation of heat and power (CHP) that is not for own use but delivered to other sectors and/or the general grid (cf. Section 2). Since the 1990s capacity for CHP in the Dutch Agricultural sector has become substantial, inducing annual savings of around 2 PJ (cf. Boonekamp 1998: 81).

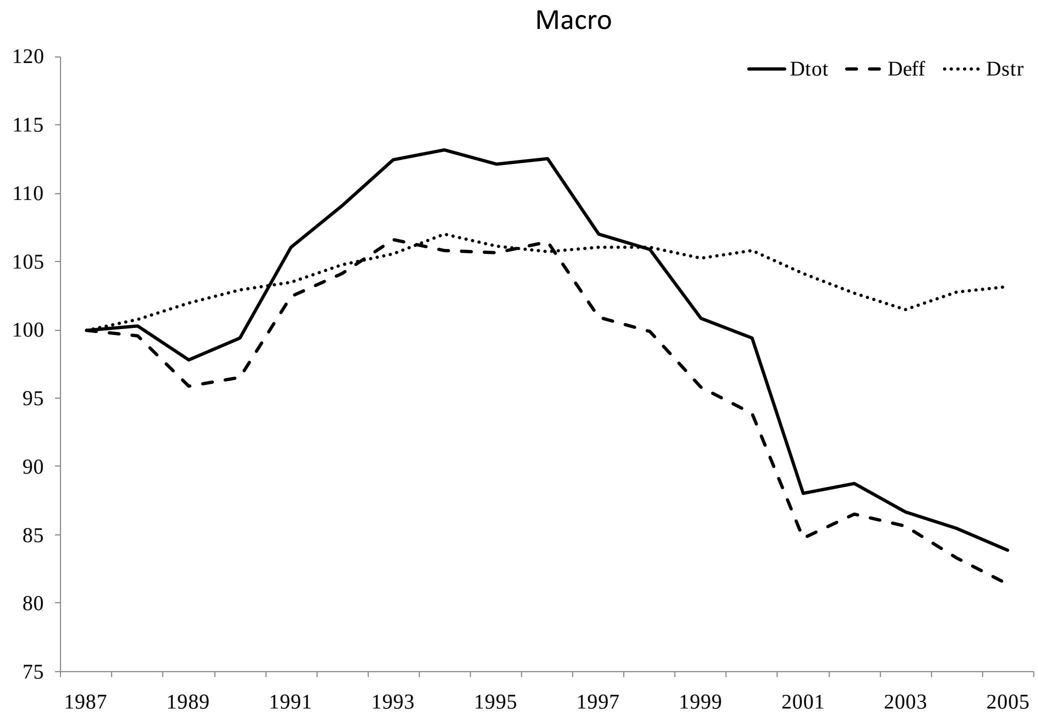
Table 4.2 Average annual growth rates energy intensity by sector.

Average annual growth rates	1987−2005		1987−1995		1995−2005			
	NLD	OECD	NLD	OECD	NLD	OECD	EU-12	EU-4
Macro	–0.9	–0.9	1.5	0.5	–2.8	–2.0	–2.2	–1.4
Macro*	–0.4	–2.0	1.4	–0.9	–1.7	–2.9	–1.7	–2.8
Manufacturing	–0.2	–2.1	1.1	–0.3	–1.3	–3.7	–1.4	–5.2
Services	0.4	–1.3	2.7	–1.2	–1.4	–1.5	–0.8	–2.4
Transport	–2.3	–0.7	0.4	–0.8	–4.5	–0.7	–2.3	3.4
Agriculture	–1.1	–1.8	–2.4	–0.6	–0.1	–2.6	–2.3	–4.4
Construction	2.8	0.1	6.2	0.0	0.2	0.2	–1.4	–1.9

Macro* = Agriculture + Manufacturing + Services

As argued in Section 3, changes in energy intensity at the aggregate economy level result not only from technology-driven efficiency improvements in individual sectors, but also from changes in the sector composition of the economy. By using index number decomposition (or shift-share) analysis, we are able to decompose changes in aggregate energy productivity into a so-called structure effect and an efficiency effect. The structure effect measures the change in the economy’s energy intensity due to the changing composition of activities within the economy. The efficiency effect, in contrast, measures changes due to efficiency improvements within each sector at a constant sector structure. In Figure 4.4 we present the results of our decomposition analysis for the Dutch economy by plotting the indexed evolution of aggregate energy intensity (*Dtot*), the efficiency effect (*Deff*) and the structure effect (*Dstr*). We do so at two levels of aggregation: (i) *Macro*, including the sectors Manufacturing, Services, Transport, Agriculture and Construction; and (ii) *Macro**, including only the sectors Manufacturing, Services and Agriculture.

Figure 4.4 leads to a couple of observations. First, changes in aggregate energy intensity are predominantly influenced by changes in within-sector efficiency levels. Second, throughout the period 1987–2005, structural changes have for the most part contributed to a higher level of aggregate energy intensity: once we correct for the structure effect, aggregate energy intensity would have been lower (indicated by the line *Deff*). Third, between 1989 and 1996, both structural changes and negative within-sector energy efficiency growth have contributed to increasing aggregate energy intensity levels. Consistent with results presented in Table 4.1, the top figure (Macro) shows that aggregate energy intensity in 2005 was about 15% percent point lower than in 1987. However, the figure below (Macro*) shows that if we exclude the Transport and Construction sector aggregate energy intensity in 2005 was only about 7% points lower than in 1987. In addition, at the Macro* level structural changes have since 2000 contributed to a lower level of aggregate energy intensity – contrary to the period before 2000 and in contrast to what we found at the Macro level (top figure).



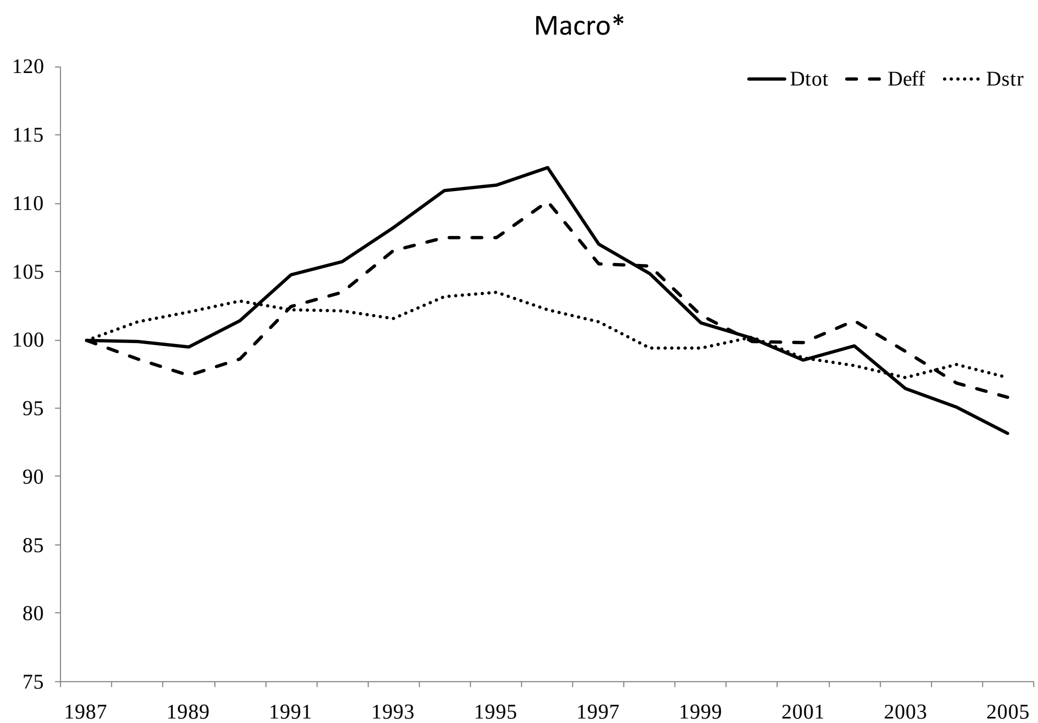


Figure 4.4 Decomposition of aggregate energy intensity development (Dtot) into a structure effect (Dstr) and efficiency effect (Deff); (index, 1987=100). Macro[*] = Agriculture + Manufacturing + Services

Table 4.3 Percentage contribution of the efficiency effect and the structural effect by sector to the average annual growth rate of energy intensity in the Netherlands.

Macro	**1987–2005**			**1987–1995**			**1995–2005**		
	Efficiency Effect	Structure Effect	Total Effect	Efficiency Effect	Structure Effect	Total Effect	Efficiency Effect	Structure Effect	Total Effect
Manufacturing	–7.9	–9.5	–17.4	23.1	4.7	27.8	–14.6	–7.5	–22.1
Services	7.4	2.4	9.8	28.0	–1.4	26.7	–8.9	2.1	–6.8
Transport	–104.4	24.5	–80.0	12.4	34.5	46.9	–65.7	0.8	–64.9
Agriculture	–12.4	–0.7	–13.0	–15.4	12.5	–3.0	–0.3	–5.5	–5.8
Construction	1.6	–0.9	0.6	2.0	–0.4	1.6	0.0	–0.4	–0.4
MACRO	–115.8	15.8	–100.0	50.1	49.9	100.0	–89.5	–10.5	–100.0

Macro*	**1987–2005**			**1987–1995**			**1995–2005**		
	Efficiency Effect	Structure Effect	Total Effect	Efficiency Effect	Structure Effect	Total Effect	Efficiency Effect	Structure Effect	Total Effect
Manufacturing	–32.8	–47.3	–80.1	44.8	9.2	54.0	–39.8	–23.5	–63.3
Services	30.7	6.1	36.7	54.3	–2.6	51.8	–24.3	4.1	–20.2
Agriculture	–51.5	–5.2	–56.7	–29.9	24.2	–5.7	–0.8	–15.8	–16.5
MACRO	–53.6	–46.4	–100.0	69.2	30.8	100.0	–64.9	–35.1	–100.0

Macro* = Agriculture + Manufacturing + Services

In order to examine the role of individual sectors in driving the results presented in Figure 4.2, we identify for each individual sector the percentage contribution of the total efficiency effect and the total structural effect to the aggregate growth rate of energy intensity. The results are presented in Table 4.3, again for the three different time periods and distinguishing the Macro level (Table 4.3a) from the Macro* level (Table 4.3b). The bottom lines confirm that aggregate energy intensity decreased during the period 1987–2005 and 1995–2005, but increased during the period 1987–1995. It also confirms that changes in aggregate energy intensity are predominantly influenced by changes in within-sector efficiency levels. At the same time, Table 4.3 makes clear that structural changes play an important role, particularly at the Macro* level. At this level, structural changes explain about 46% of total aggregate change in energy intensity between 1987 and 2005, and 30–35% in the two different sub-periods. At the Macro level the total impact of changes in the sector composition is much smaller (10–15%), except for the period 1987–1995 when they explain about 50% of aggregate energy intensity increase. The sector breakdown provided in the top table clearly illustrates that – consistent with Table 4.1 – at the Macro level the decrease in aggregate energy intensity between 1987 and 2005 is mainly due to energy efficiency improvements in the Transport sector, followed by the Agricultural sector (before 1995) and the Manufacturing sector (after 1995). At the Macro* level the decrease in aggregate energy intensity between 1987 and 2005 is driven by within-sector efficiency improvements in Agriculture (between 1987 and 1995) and Manufacturing (between 1995 and 2005) in combination with a structural shift away from Manufacturing (after 1995). Increasing energy intensity in the Service sector caused a slowdown of the fall in aggregate energy intensity, mainly because of decreasing energy efficiency between 1987 and 1995.

To put these results in an international perspective, we provide in Figure 4.5 for the three different time periods the average annual growth rates of energy intensity in the Netherlands at the aggregate economy level (Macro) as compared to other OECD countries, before and after correcting for the impact of changes in the sectoral composition of the economy. The left side of Figure 4.3 provides average annual energy intensity growth rates before decomposition (gross) and the right side provides energy intensity growth rates after correction for the impact of structural changes (net). From the Figure it can be seen that the Netherlands ranks on average both in terms of gross and net aggregate energy intensity performance. For the period 1987–2005 the Figure confirms a negative annualized growth rate of aggregate energy intensity in the Netherlands of –0.9 % (cf. Table 4.1 and 4.2), which increases slightly to about –1% after correcting for the impact of structural shifts. This is substantially lower than the performance of Denmark – with its average annual decrease of about 4% – but much higher than a country like the United Kingdom – with an average annual increase of 0.69% (gross) and 1.22% (net), respectively. For the period 1995–2005 we find that structural shifts contributed only modestly to aggregate average energy intensity in the Netherlands: after correcting for the impact of structural shifts the annualized growth rate decreases from –2.8% to –2.5%.

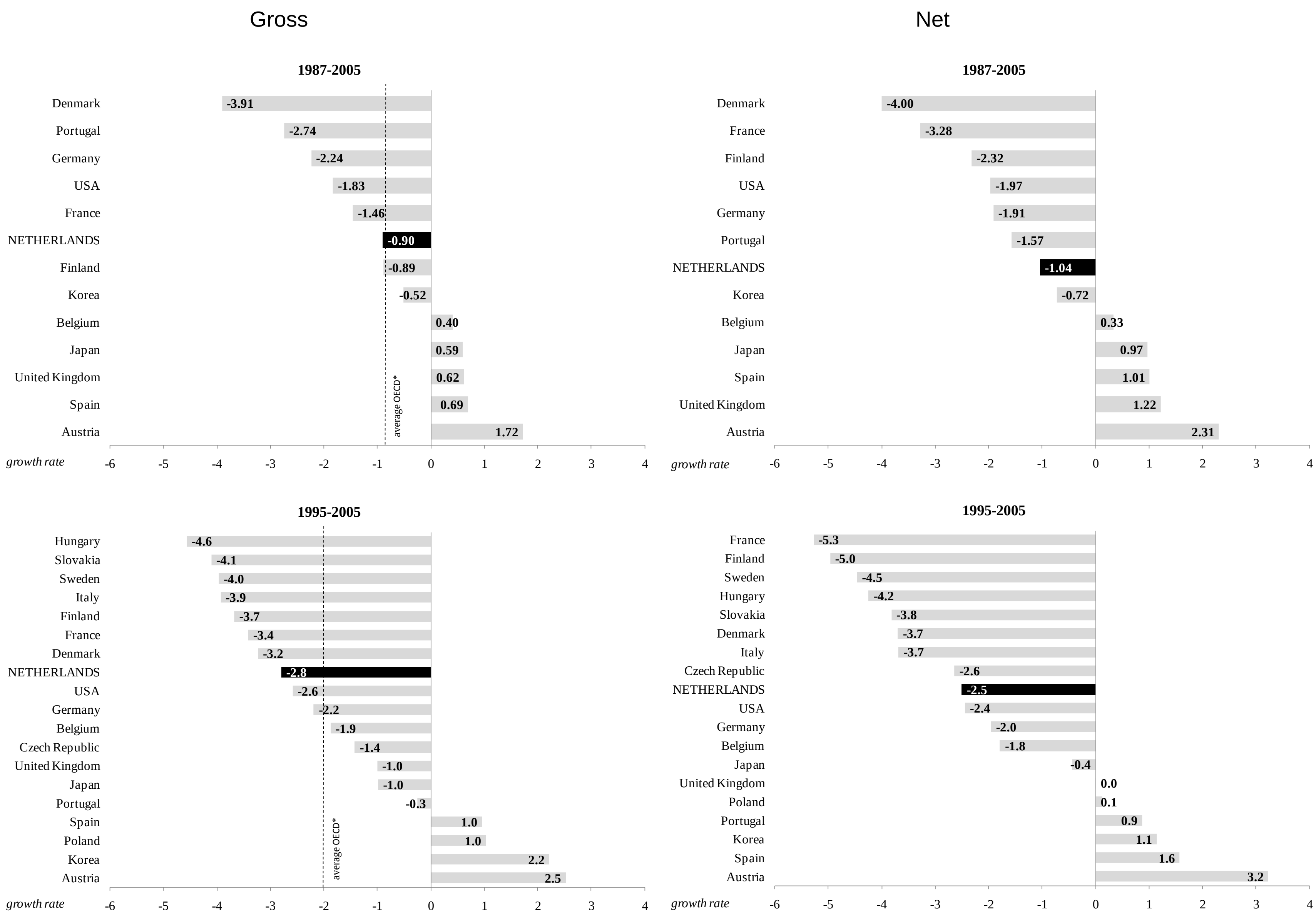


Figure 4.5 Average annual growth rate of aggregate energy intensity before (gross) and after (net) correcting for structural changes

We conclude this section by taking a closer at energy intensity *levels* in the Netherlands, as compared to the OECD average. The results are presented in Figure 4.6 for three years (1987, 1995 and 2005). To facilitate interpretation, we present the results in Figure 4.6 in terms of energy productivity, i.e. the inverse of energy intensity. A relatively good performance of the Netherlands is then defined as a relatively high level of *energy productivity*, which corresponds to a relatively low level of energy intensity. Again, we distinguish the aggregate economy level (Macro) and the sectors Manufacturing, Services, Transport, Agriculture and Construction.

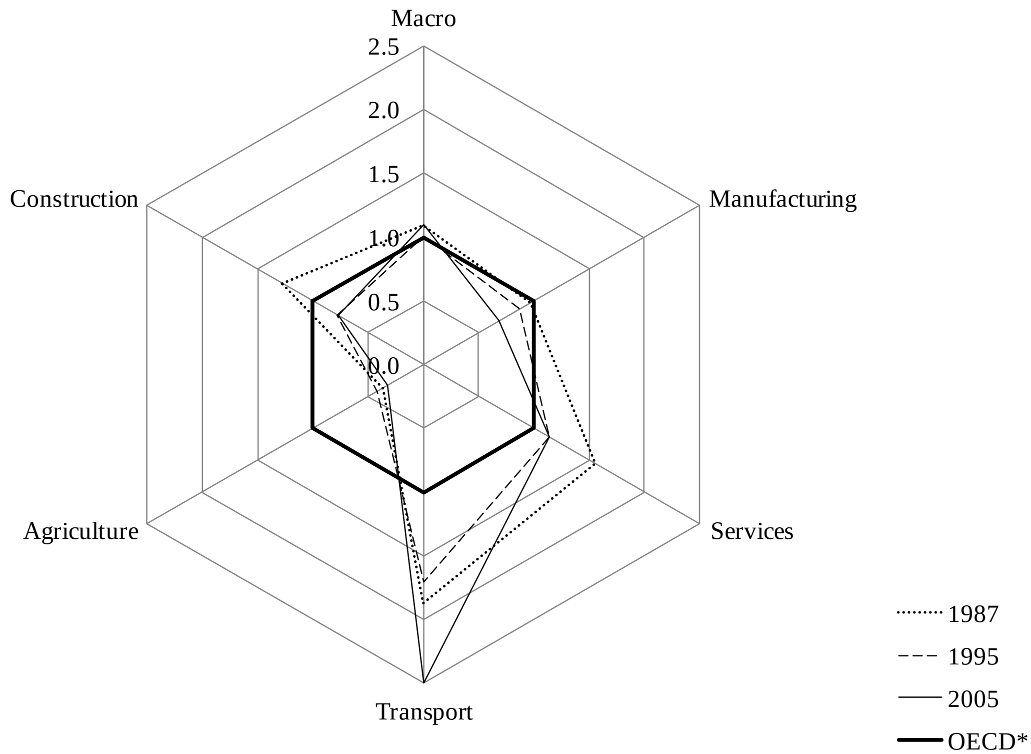


Figure 4.6 Energy productivity levels in the Netherlands relative to the OECD average.

Figure 4.6 shows that, as noted before, at the aggregate economy level the performance of the Netherlands is very close to the OECD average. The same is true for Manufacturing, although over time energy productivity performance tends to fall below the OECD average. In the next section we explore this development in more detail. In Services, the energy productivity level in the Netherlands was about 50% higher than the OECD average in 1987, but this lead has almost disappeared by 2005. A similar development has occurred in the Construction sector. In Agriculture, energy productivity levels in the Netherlands are considerably lower than the OECD average, for all years included. As noted several times before, this is due to the important role of energy intensive horticulture in the Dutch Agricultural sector. In contrast, in Transport energy productivity levels in the Netherlands are much above the OECD average, again for all years included. We refer to the aforementioned arguments regarding the difficulties to interpret this result.

5. Manufacturing

In this section we analyze the development of energy intensity in the Dutch Manufacturing sector, identifying the role of 25 Manufacturing sectors, consisting of 10 main sectors and 15 sub sectors. Similar to Section 4, we present in Figure 5.1 the shares of the 10 main Manufacturing sectors in aggregate Manufacturing energy consumption and aggregate value added, for the year 2005.

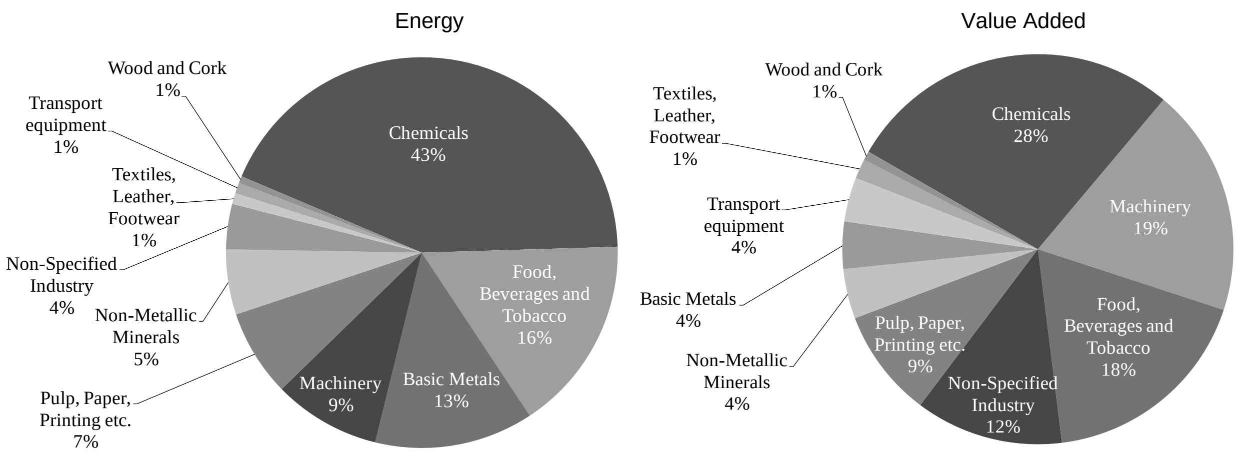


Figure 5.1. Percentage sub-sector shares of aggregate Manufacturing energy consumption and value added in the Netherlands, 2005.

From the Figure it can be seen that the Chemical sector plays a major role in Dutch Manufacturing, accounting for 43% of Manufacturing energy use and 28% of Manufacturing value added. Other large sectors include Food, Machinery, and Paper – both in terms of value added and energy use. With 13%, Basic Metals is a large consumer of energy, but its value added share is relatively small (4%). The opposite is true for Non-Specified Industry, which includes, among others, Rubber and plastics, and Medical instruments. The shares shown in Figure 5.1 have been fairly constant since 1987, except for a considerable increase of the Chemicals share in both aggregate energy consumption and value added – which increased from, respectively, 39% and 21% in 1987 to 43% and 28% in 2005.

In Figure 5.2 we compare these shares with the average OECD shares. Again, values are indexed, relative to the OECD average as denoted by the axes (OECD = 1.0). The Figure shows that relative to the OECD average, the Netherlands specializes in the sectors Chemicals, Food and beverages, Fabricated metal, Printing etc., and Manufacturing not elsewhere classified (including Recycling). A comparison of the figures for 1987 and 2005 shows again the increasing relative importance of the Chemical sector, as well as growth of the sector Fabricated Metal (which is part of the Machinery sector) and the sector Printing, Publishing and Reproduction. Especially electrical engineering became considerably smaller relative to the OECD average.

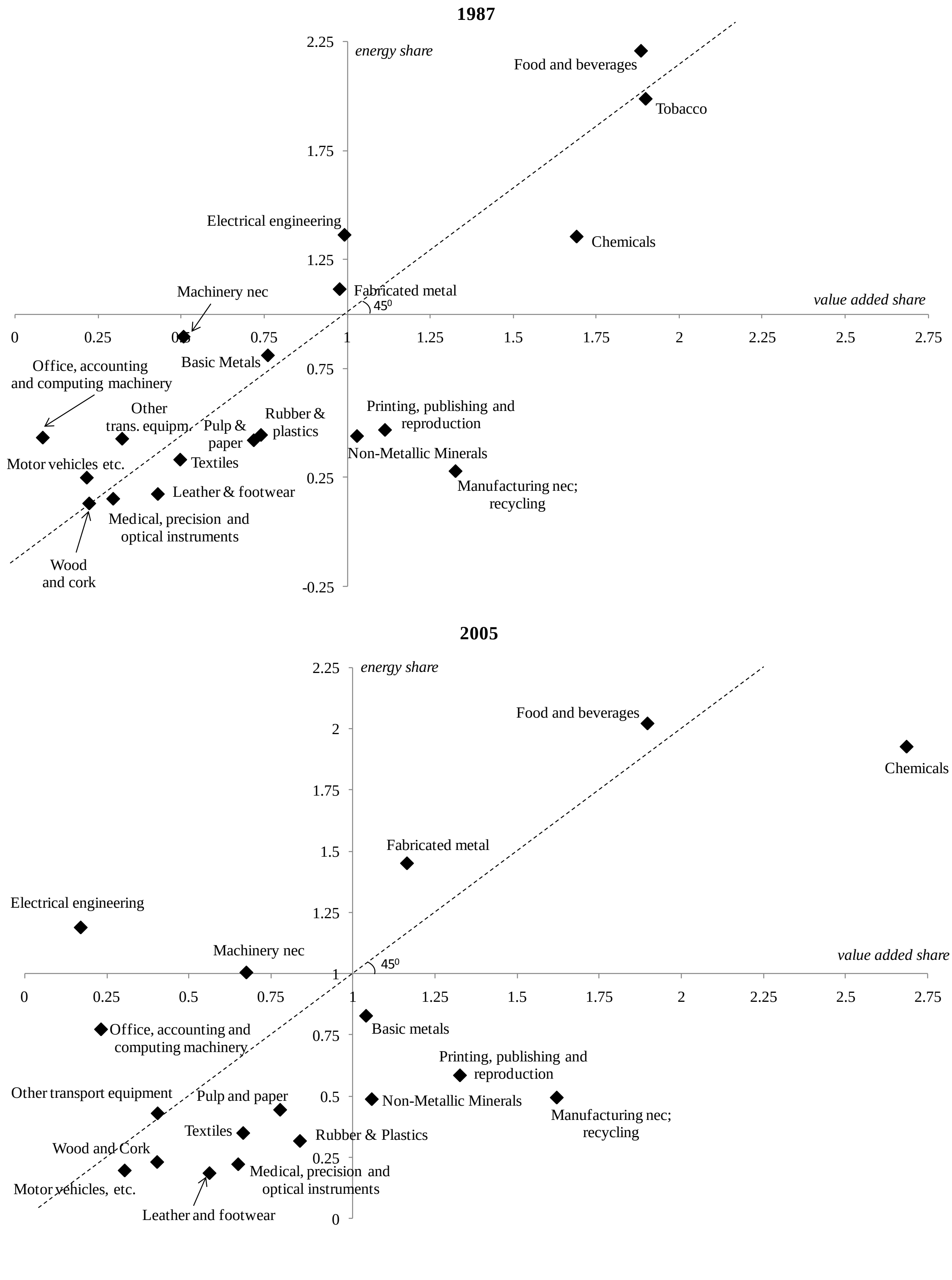


Figure 5.2 Share of Dutch manufacturing sectors in total Manufacturing value added and energy use in 1987 and 2005, relative to OECD average (OECD=1.0).

Again, points on the dashed diagonal line are points where the sectoral energy intensity is the same as the aggregate OECD average. Sectors to the Northwest are relatively energy intensive, whereas sectors to the South East are energy extensive. From Figure 5.2 it can be seen that energy intensity in the Chemicals sector is considerably below the OECD average (situated left of the 45^0 degree line). In addition, the Figure shows that this is also true for many other, smaller, sectors. In fact, in a large part of the Dutch industry energy intensity levels are below the OECD average. This includes sectors as diverse as Basic Metals, Paper and Printing etc., Non-Metallic Minerals, Rubber and Plastics, and Medical instruments. Only in a few sectors, such as Office Machinery and Machinery not elsewhere classified, energy intensity is structurally below the OECD average.

To gain more insight into the development of energy intensity over time, we present in Table 5.1 for three different time periods the average annual growth rate of energy intensity and its components: energy use and value added. We do so for the aggregate economy level as well as individual main sectors. To facilitate comparison and interpretation of our data, we also provide the average annual growth rates of, respectively, energy use according to IEA data, value added according to STAN data, as well as energy intensity according to the combination of these two data sources. Because of limited sector detail in the IEA classification we are able to do so only for the aggregate Manufacturing level and the ten main Manufacturing sectors.

Table 5.1a shows that at the aggregate Manufacturing level, between 1987 and 2005, energy intensity in the Netherlands decreased with an average 0.2% per year. The first column of the Table shows that this decrease largely results from a fall in energy intensity in the energy intensive sectors Chemicals and Basic Metals. In contrast, energy intensity increased particularly in the sectors Wood and Cork, Printing etc., and Machinery. The third and fifth column of Table 5.1a show that these trends have been irregular over time. Most remarkable, between 1987 and 1995, aggregate Manufacturing energy intensity levels increased with 1.1% per year, which was driven by increasing energy intensity levels in all sectors except for a few small sub-sectors, particularly Office Machinery. After 1995, aggregate Manufacturing energy intensity fell with 1.3% per year, driven by developments in most Manufacturing sub-sectors, including the large energy intensive ones. The latter result confirms figures presented by other sources, including Boonekamp et al. (2002) and Neelis et al. (2007).

As noted before, the Chemical sector dominates this overview of the Manufacturing sector in the Netherlands, both in terms of value added and in terms of energy use. Moreover, as argued in Section 2, contrary to the IEA statistical system intermediate energy inputs within the EU KLEMS framework include non-energy use of fuel, and especially in the (Petro-) Chemical industry non-energy use makes up for a substantial part of total energy use. For these reasons we distinguish in Table 5.1 also aggregate Manufacturing sector excluding Chemicals. Table 5.1a shows that once we exclude Chemicals, energy intensity in the aggregate Manufacturing sector decreased on average with only 0.1% per year between 1987 and 2005. This result is the product of a 1.1% average annual increase in energy intensity between 1987 and 1995 followed by a 1.0% average annual decrease after 1995.

In a recent evaluation of the Convenant Benchmarking Energy-Efficiency in the Netherlands, De Buck et al. (2010) conclude that the partaking energy-intensive industries realized an annual average 0.5% energy saving over the period 1999–2007 (averaging out 0.8% between 1999 and 2004 and 0% between 2005 and 2007). For approximately the same sample of industries (Food and beverages, Paper etc., Non-Metallic Minerals and Basic Metals – but excluding Chemicals because of feedstock use; see Section 2) our data indicate a similar, although slightly better performance: an average energy intensity decrease of 1% per year over the period 1999–2005, and 1.2% over the period 1999–2004 (which match up relatively well with the 0.8% reported by De Buck et al. (2010) for the same period). In comparison, for the period 1999–2005 our data indicate an average annual energy intensity decrease of 1.2% for the Manufacturing sector as a whole, and a 0.5% decrease for Manufacturing excluding Chemicals.

Table 5.1a Change in Manufacturing energy intensity.

Average annual growth rates	Energy Intensity					
	1987−2005		1987−1995		1995−2005	
	EUK	IEA	EUK	IEA	EUK	IEA
MANUFACTURING	–0.2	–1.5	1.1	–3.7	–1.3	0.2
MANUFACTURING without CHEMICALS	–0.1	–0.1	1.1	–0.5	–1.0	0.2
FOOD , BEVERAGES AND TOBACCO	–0.4	0.1	0.3	–1.1	–1.0	1.1
Food and beverages	–0.3		0.5		–1.0	
Tobacco	–1.5		–2.3		–0.9	
TEXTILES, LEATHER AND FOOTWEAR	–0.1	0.1	2.6	4.1	–2.2	–3.1
Textiles	–0.3		2.2		–2.2	
Leather and footwear	1.3		6.8		–2.9	
WOOD AND CORK	2.5	–0.9	6.2	–3.0	–0.4	0.8
PULP, PAPER , PRINTING AND PUBLISHING	0.3	1.0	1.2	–2.3	–0.5	3.7
Pulp and paper	–0.4		2.2		–2.3	
Printing, publishing and reproduction	0.9		1.7		0.2	
CHEMICALS	–1.3	–2.9	0.6	–5.4	–2.8	–0.8
NON–METALLIC MINERALS	1.0	–1.7	2.0	–1.6	0.2	–1.8
BASIC METALS	–0.6	–1.4	2.4	–1.6	–3.0	–1.2
MACHINERY	0.7	1.4	1.6	–0.2	0.0	2.8
Fabricated metal	0.9		0.8		1.0	
Machinery n.e.c.	–0.7		0.6		–1.8	
Office, accounting and computing machinery	–9.8		–18.1		–2.6	
Electrical engineering	3.5		4.9		2.4	
TRANSPORT EQUIPMENT	–2.0	–4.3	1.0	–3.6	–4.3	–4.9
Motor vehicles, trailers and semi-trailers	–3.7		–4.8		–2.9	
Other transport equipment	–0.2		5.9		–4.8	
NON-SPECIFIED INDUSTRY	0.4	9.5	1.0	30.0	–0.1	–4.6
Rubber and plastics	–1.5		–2.1		–0.9	
Medical, precision and optical instruments	–0.9		–0.7		–1.1	
Manufacturing n.e.c.; recycling	4.5		6.8		2.7	

Table 5.1b Change in Manufacturing energy use and value added.

Average annual growth rates	Energy Use						Value Added					
	1987−2005		1987−1995		1995−2005		1987−2005		1980−1995		1995−2005	
	EUK	IEA	EUK	IEA	EUK	IEA	EUK	STAN	EUK	STAN	EUK	STAN
MANUFACTURING	2.1	0.6	3.8	–1.2	0.8	2.1	2.3	2.2	2.6	2.6	2.1	1.8
MANUFACTURING without CHEMICALS	1.7	1.7	3.6	1.9	0.2	1.5	1.8	1.8	2.4	2.4	1.3	1.4
FOOD , BEVERAGES AND TOBACCO	1.5	2.0	3.5	2.1	–0.2	1.9	1.9	1.9	3.2	3.2	0.8	0.8
Food and beverages	1.5		3.5		–0.2		1.8		3.0		0.8	
Tobacco	1.2		3.0		–0.3		2.7		5.5		0.6	
TEXTILES, LEATHER AND FOOTWEAR	–1.3	–1.2	1.9	3.4	–3.8	–4.7	–1.2	–1.2	–0.7	–0.7	–1.7	–1.6
Textiles	–1.3		1.8		–3.7		–1.0		–0.4		–1.6	
Leather and footwear	–1.6		3.7		–5.6		–2.9		–2.9		–2.8	
WOOD AND CORK	4.7	1.2	10.7	1.0	0.2	1.4	2.2	2.2	4.2	4.2	0.6	0.6
PULP, PAPER , PRINTING AND PUBLISHING	1.5	2.3	3.3	–0.2	0.1	4.4	1.2	1.3	2.1	2.1	0.6	0.6
Pulp and paper	1.3		2.9		0.0		1.7		0.7		2.4	
Printing, publishing and reproduction	2.1		4.3		0.3		1.2		2.5		0.1	
CHEMICALS	2.7	1.0	4.1	–2.1	1.5	3.6	4.0	4.0	3.6	3.6	4.4	4.4
NON-METALLIC MINERALS	1.8	–0.9	2.6	–1.1	1.2	–0.8	0.8	0.8	0.5	0.5	1.0	1.0
BASIC METALS	1.5	0.7	3.6	–0.4	–0.2	1.6	2.1	2.1	1.2	1.2	2.9	2.9
MACHINERY	2.5	3.6	4.2	2.7	1.2	4.3	1.8	2.2	2.6	3.0	1.1	1.6
Fabricated metal	3.3		4.8		2.1		2.3		3.9		1.1	
Machinery n.e.c.	2.0		2.6		1.6		2.8		2.0		3.4	
Office, accounting and computing machinery	2.6		9.1		–2.4		13.8		33.2		0.2	
Electrical engineering	2.0		4.6		–0.1		–1.5		–0.3		–2.4	
TRANSPORT EQUIPMENT	1.4	–1.2	4.5	–0.4	–1.0	–1.8	3.4	3.3	3.4	3.3	3.5	3.3
Motor vehicles, trailers and semi-trailers	1.0		–0.4		2.1		4.9		4.7		5.1	
Other transport equipment	1.6		8.3		–3.6		1.8		2.4		1.3	
NON–SPECIFIED INDUSTRY	2.9	11.7	3.6	32.3	2.4	–2.4	2.5	2.0	2.6	1.8	2.5	2.3
Rubber and plastics	1.4		2.0		1.0		2.9		4.2		1.9	
Medical, precision and optical instruments	3.9		4.0		3.9		4.9		4.7		5.0	
Manufacturing not elsewhere classified; recycling	6.1		7.8		4.7		1.5		0.9		2.0	

A comparison with energy intensity figures based on IEA information reveals that at the aggregate Manufacturing level IEA data indicate a substantial larger decrease in energy intensity during the period 1987 and 2005. As noted in the previous section, this difference is largely caused by the fact that IEA data indicate a 1.2% average annual decrease in Manufacturing energy use during the period 1987 and 1995 whereas EU KLEMS data indicate a 3.8% average annual increase (see also Table 5.1b). In Section 4 we have argued that these differences are likely due to the different treatment of non-energy use of fuel in the two data sources. The numbers presented in Table 5.1b confirm this conjecture: according to IEA data the change in energy use in the Chemical sector is substantially lower than according to EU KLEMS data. Consequently, once we exclude the Chemicals sector, energy use and thus energy intensity figures based on IEA data and EU KLEMS data are identical for the period 1987 to 2005 while differences are relatively small for the other periods. In the Textile sector differences are also very small. Nevertheless, in most sub-sectors substantial differences remain to exist between IEA and EU KLEMS energy use data, implying differences in energy intensity figures. IEA data reveal a much lower increase (or even decrease) in energy use than EU KLEMS in the sectors Non-metallic minerals, Transport equipment, Basic Metals (after 1995) and Wood, while the contrary is true for the Machinery sector as well as the Paper and Food sectors after 1995. As a result, using IEA data leads to a much higher estimate of the decrease in energy intensity in energy intensive sectors like Chemicals, Non-metallic minerals and Basic Metals as well in the sectors Wood and Transport equipment. The opposite is true for Non-specified industry, Machinery and Paper.

We continue our descriptive analysis by taking a closer look at the development of energy intensity *levels* over time in time. In Figure 5.3 we show this development (index: 1987=100) for 19 Dutch manufacturing sectors, including 15 sub-sectors and 4 main sectors for which no sub-sector detail is available (cf. Table 5.1). The Figure clearly shows that, with a few exceptions, energy intensity levels in sum have changed only very little in most Manufacturing sectors. The Figure also reveals for most Manufacturing sectors a tendency of increasing energy intensity levels between 1989 and 1997, and decreasing energy intensity levels afterwards. Major exceptions are Manufacturing n.e.c. (including Recycling), Electrical Engineering and Office Machinery; the first two are characterized by a large and structural increase in energy intensity whereas the latter is characterized by a structural lower level of energy intensity since a sharp fall in energy intensity between 1987 and 1993. Finally, in the sector Leather and Footwear energy intensity fluctuates sharply over time.

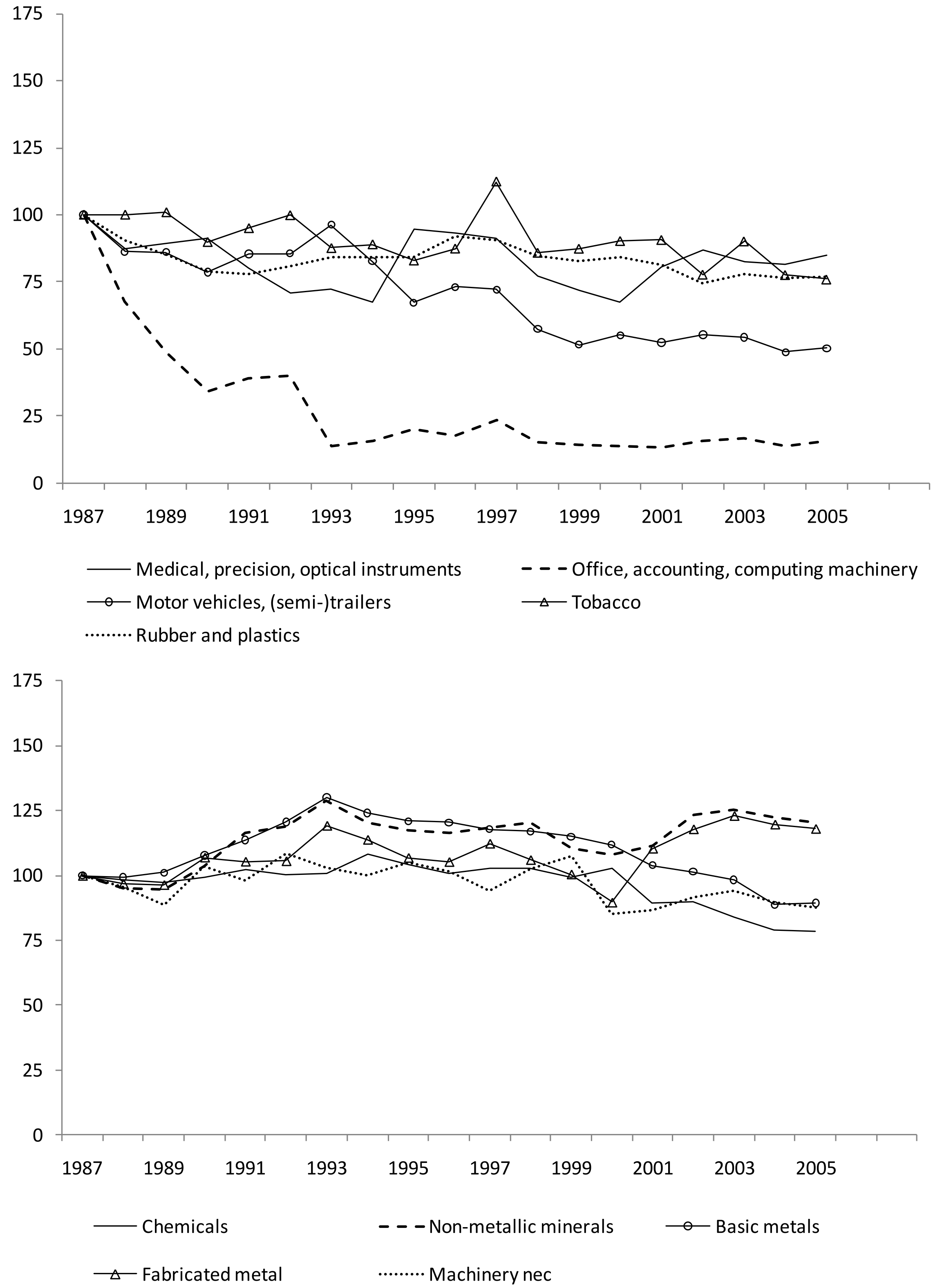


Figure 5.3a, b. Development of energy intensity by manufacturing sector (index, 1987=100)

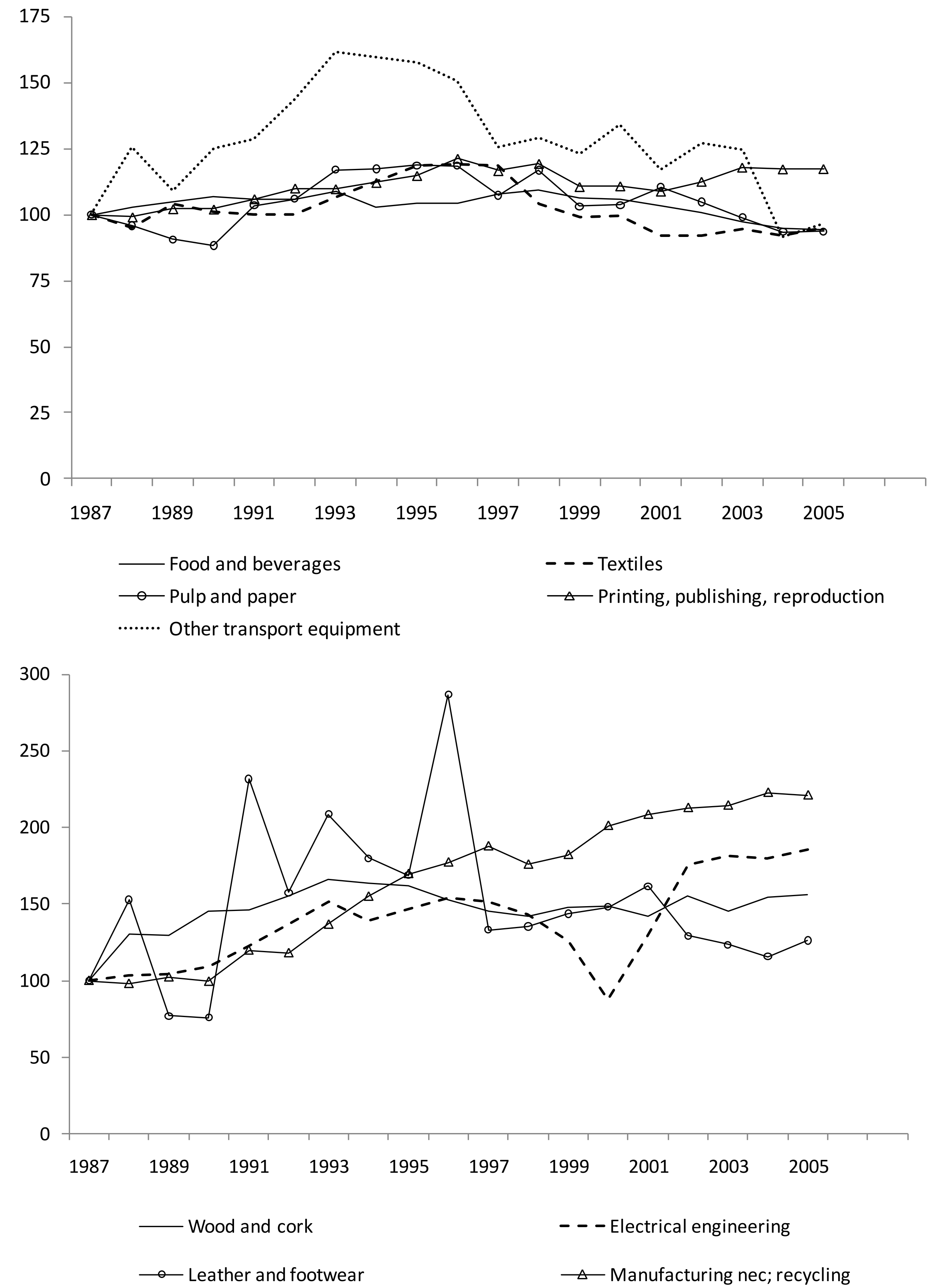


Figure 5.3c, d. Development of energy intensity by manufacturing sector (index, 1987=100)

To put these trends in an international perspective, we provide in Table 5.2 the annualized growth rates of energy intensity in the Netherlands, in comparison with the OECD average. The Table shows that at the aggregate Manufacturing level performance is below the OECD average in all three time periods, but especially during the period 1987–1995. Also in comparison with EU averages the Netherlands performs relatively poor (after 1995). At the sector level, measured over the whole period 1987–2005, the Netherlands performs below the OECD average in all sectors and time periods, except in Tobacco and Rubber and plastics. Between 1987 and 1995, except for these two sectors, this is also true for Office Machinery and Motor vehicles etc. After 1995, performance in the Netherlands is above OECD average as well as above EU-12 average in several more sectors, including Textiles, Basic Metals and Other Transport Equipment.

Table 5.2 Average annual growth rates manufacturing energy intensity by sub sector.

Average annual growth rates	1987−2005		1987−1995		1995−2005			
	NLD	OECD	NLD	OECD	NLD	OECD	EU-12	EU-4
MANUFACTURING	–0.2	–2.1	1.1	–0.3	–1.3	–3.7	–1.4	–5.1
MANUFACTURING without CHEMICALS	–0.1	–2.0	1.1	–0.2	–1.0	–3.5	–1.1	–6.8
FOOD , BEVERAGES AND TOBACCO	–0.4	–0.6	0.3	–0.7	–1.0	–0.6	0.7	–2.7
Food and beverages	–0.3	–1.7	0.5	–2.0	–1.0	–1.4	0.1	–2.9
Tobacco	–1.5	3.0	–2.3	1.1	–0.9	3.8	1.1	0.9
TEXTILES, LEATHER AND FOOTWEAR	–0.1	–0.6	2.6	–0.5	–2.2	–0.7	0.3	–3.0
Textiles	–0.3	–0.9	2.1	–0.9	–2.2	–0.9	0.1	–2.3
Leather and footwear	1.3	0.5	6.6	0.5	–2.9	0.3	1.1	–8.1
WOOD AND CORK	2.5	0.5	6.0	1.8	–0.4	–0.4	1.7	–0.1
PULP, PAPER , PRINTING AND PUBLISHING	0.3	–1.4	1.2	0.8	–0.5	–3.1	–0.4	0.3
Pulp and paper	–0.4	–2.0	2.1	1.5	–2.4	–4.7	–1.8	–0.2
Printing, publishing and reproduction	0.9	–1.1	1.7	–1.0	0.2	–0.9	–0.5	–0.5
CHEMICALS	–1.3	–2.6	0.6	–0.9	–2.8	–4.1	–2.9	5.2
NON-METALLIC MINERALS	1.0	–1.4	2.0	–2.1	0.2	–0.9	–0.2	–11.4
BASIC METALS	–0.6	–0.9	2.4	0.0	–3.0	–1.5	0.2	0.2
MACHINERY	0.7	–4.3	1.6	–2.5	0.0	–5.3	–2.5	–9.8
Fabricated metal	0.9	–1.2	0.8	–1.2	1.0	–1.1	–1.1	–8.4
Machinery n.e.c.	–0.7	–1.7	0.6	–1.3	–1.8	–2.0	–1.2	–8.2
Office, accounting and computing machinery	–10.3	–10.0	–20.0	–8.1	–2.6	–11.0	–8.5	–17.6
Electrical engineering	3.4	–7.6	4.8	–4.5	2.3	–10.1	–5.5	–10.1
TRANSPORT EQUIPMENT	–2.0	–1.8	1.0	–0.8	–4.4	–2.6	–1.3	–10.5
Motor vehicles, trailers and semi-trailers	–3.8	–2.5	–5.0	–1.3	–2.9	–3.4	–1.2	–14.4
Other transport equipment	–0.2	–0.9	5.7	–0.5	–4.9	–1.2	–2.5	–1.1
NON-SPECIFIED INDUSTRY	0.4	–0.2	0.9	1.4	–0.1	–1.2	–0.3	–6.7
Rubber and plastics	–1.5	–0.8	–2.1	–0.1	–0.9	–1.4	–0.6	–6.2
Medical, precision and optical instruments	–0.9	–0.6	–0.7	1.5	–1.1	–2.1	–3.5	–0.5
Manufacturing n.e.c.; recycling	4.4	0.2	6.6	1.6	2.6	–0.8	1.6	–7.6

Also at the aggregate Manufacturing level, changes in energy intensity result not only from technology-driven efficiency improvements in individual Manufacturing sectors (efficiency effect), but also from changes in composition of the Manufacturing sector in terms of the mix of sub sectors (structure effect). Again, we use index number decomposition (or shift-share) analysis to decompose changes in aggregate Manufacturing energy intensity into this structure and efficiency effect. In Figure 5.4 we present the results of our decomposition analysis for the Dutch Manufacturing sector by plotting the indexed evolution of aggregate energy intensity (*Dtot*) and the relative importance of the efficiency effect (*Deff*) and structure effect (*Dstr*). We do so for: (i) Manufacturing; and (ii) Manufacturing excluding Chemicals.

From Figure 5.4 it can be seen that since 1987 for most of the time changes in aggregate manufacturing energy intensity are predominantly influenced by within-sector efficiency developments. Between 1990 and 2000, both the increase and subsequent decrease of manufacturing energy intensity are primarily driven by an efficiency effect. During the same period, structural changes played only a minor role, in the form of slightly slowing down the increase in Manufacturing energy intensity. Since 2000, however, structural changes have started to play an important and different role. More specifically, since 2000 changes in the industry product mix have contributed substantially to increasing energy intensity at the aggregate manufacturing level, thus reversing the pre-2000 situation. In correspondence with results presented in Table 5.1, the top figure shows that aggregate energy intensity in 2005 was about 4% percent point lower than in 1987. However, if we exclude Chemicals, the bottom figure shows that aggregate energy intensity in 2005 was virtually the same as in 1987. In addition, once we exclude Chemicals, structural changes have contributed considerably to a lower level of aggregate energy intensity – whereas the efficiency effect was predominantly negative, i.e. it contributed for the most part to increasing energy levels, except for the last two years of the period under consideration.

In order to examine the role of individual sectors in driving these results, we identify for each individual Manufacturing sector the percentage contribution of the total efficiency effect and the total structural effect to the growth rate of energy intensity at the aggregate Manufacturing level. The results are presented in Table 5.3, again for the three different time periods. The bottom line of the Table 5.3 confirms that aggregate energy intensity decreased during the period 1987–2005 and 1995–2005, but increased during the period 1987–1995. It also confirms that changes in aggregate Manufacturing energy intensity are predominantly influenced by changes in within-sector efficiency levels, as long as we include Chemicals. In this case, between 1987 and 2005 about half of the efficiency improvements were undone by shift towards a more energy-intensive industry structure (133.6% as compared to –233%); between 1995 and 2005 with this percentage is about one-third. In contrast, between 1987 and 1995 structural changes contribute marginally (with 5.4%) to a decrease in aggregate energy intensity. Once we exclude Chemicals, structural changes even explain all decrease in energy intensity (with 108.6%) between 1987 and 2005, while within-sector energy efficiency changes together contribute to a small increase (8.6%) in aggregate Manufacturing energy intensity. These outcomes result mainly from developments in the period 1987–1995; after 1995 within-sector energy efficiency improvements by far dominate structural effects – driving down energy intensity for the Manufacturing sector as a whole.

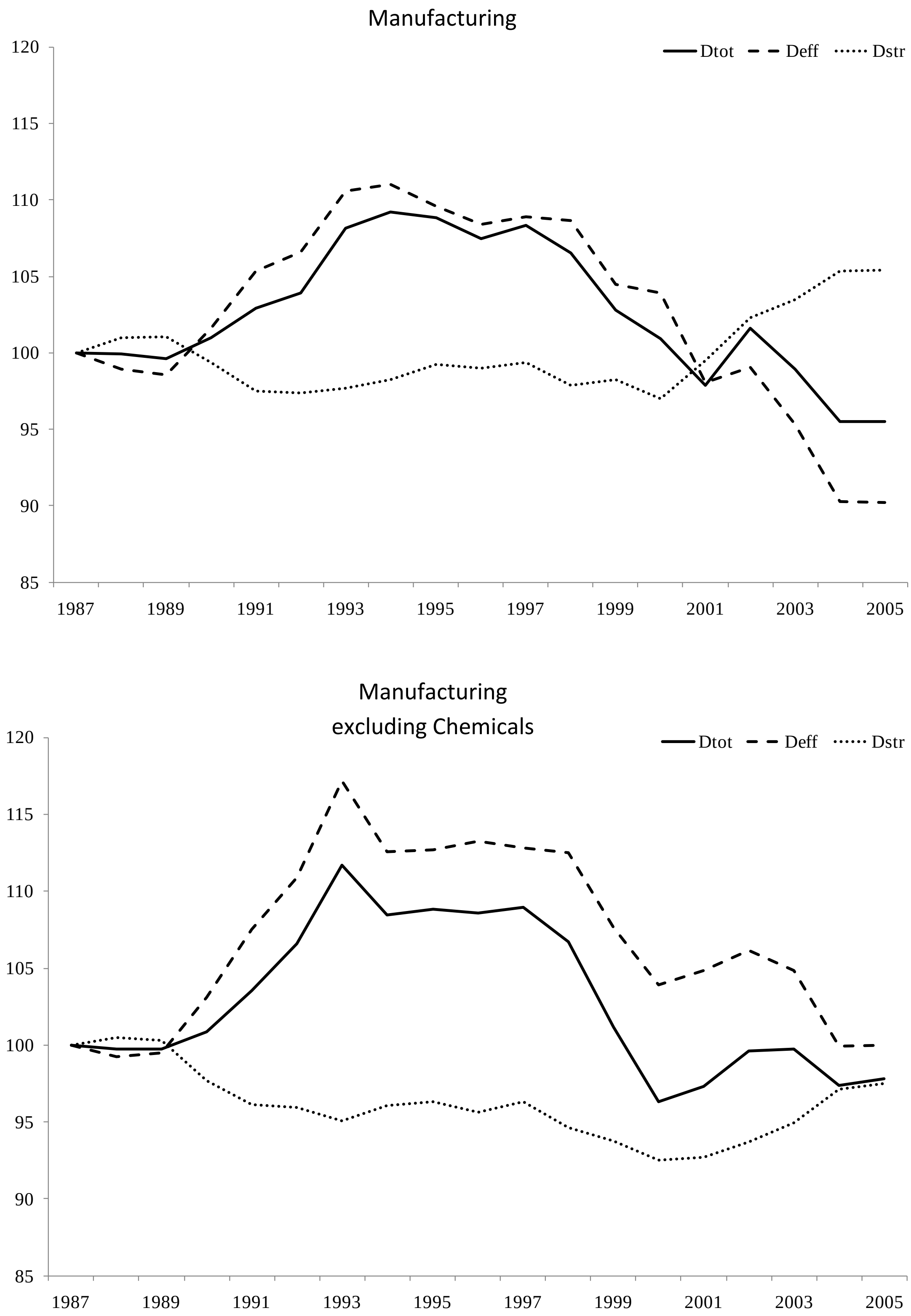


Figure 5.4 Decomposition of manufacturing energy intensity development (Dtot) into a structure effect (Dstr) and efficiency effect (Deff); (index, 1987=100)

Table 5.3 Average percentage contribution of the efficiency effect and the structural effect by Manufacturing sub sector to the average annual growth rate of energy intensity in the Dutch manufacturing sector.

	1987–2005			**1987–1995**			**1995–2005**		
	Efficiency Effect	Structure Effect	Total Effect	Efficiency Effect	Structure Effect	Total Effect	Efficiency Effect	Structure Effect	Total Effect
Food and beverages	–24.0	–38.0	–62.0	8.5	5.1	13.6	–13.2	–15.6	–28.8
Tobacco	–2.0	0.5	–1.5	–0.7	0.8	0.1	–0.2	–0.3	–0.5
Textiles	–1.5	–17.3	–18.8	3.0	–4.2	–1.2	–1.9	–3.1	–5.1
Leather and footwear	0.3	–1.3	–1.0	0.5	–0.4	0.1	–0.1	–0.2	–0.4
Wood and Cork	4.9	–0.3	4.6	2.7	0.7	3.4	–0.2	–0.7	–0.9
Pulp and paper	–8.2	–14.9	–23.1	10.8	–9.7	1.0	–9.3	1.4	–8.0
Printing, publishing, etc.	8.8	–11.4	–2.6	3.8	–0.3	3.5	0.4	–3.6	–3.2
Chemicals	–235.2	290.7	55.5	20.3	31.5	51.8	–92.3	74.1	–18.2
Non-Metallic Minerals	24.6	–36.4	–11.8	10.1	–10.5	–0.4	1.0	–4.4	–3.4
Basic Metals	–37.0	–13.2	–50.2	32.1	–19.9	12.2	–32.5	8.4	–24.1
Fabricated metal	13.3	0.1	13.3	2.4	3.5	5.9	2.7	–2.6	0.1
Machinery n.e.c.	–6.9	4.1	–2.8	1.2	–1.4	–0.2	–3.0	2.2	–0.8
Office machinery, etc.	–7.5	7.7	0.2	–3.7	4.9	1.1	–0.4	–0.3	–0.7
Electrical engineering	41.1	–45.1	–4.1	13.0	–8.0	5.0	5.2	–10.0	–4.7
Motor vehicles, trailers, etc.	–8.1	5.3	–2.9	–2.1	0.8	–1.3	–1.0	1.0	0.0
Other transport equipment	–0.4	–1.1	–1.5	3.0	–0.2	2.8	–2.1	–0.3	–2.4
Rubber and plastics	–13.8	5.2	–8.6	–4.3	2.9	–1.4	–1.5	–0.2	–1.7
Medical instruments etc.	–1.0	2.6	1.6	–0.1	0.4	0.2	–0.2	0.6	0.3
Manufacturing n.e.c.; recycling	19.1	–3.6	15.4	5.1	–1.4	3.7	2.4	–0.1	2.3
MANUFACTURING	–233.6	133.6	–100.0	105.4	–5.4	100.0	–146.2	46.2	–100.0
MANUFACTURING without Chemicals	8.1	–108.1	–100.0	138.9	–38.9	100.0	–113.7	13.7	–100.0

The sectoral breakdown in Table 5.3 shows that the overall decrease in Manufacturing energy intensity between 1987 and 2005 is mainly driven by developments in Food and Beverages, Textiles, Pulp and Paper, and Basic Metals. The contribution of Textiles is mainly caused by a structural effect, while in Food and Beverages, Pulp and Paper and Basic Metals structural changes and energy efficiency improvements reinforce each other in their contribution to a decreasing aggregate manufacturing energy intensity level. In addition, the Table shows that structural change and energy efficiency improvements oppose each other in the sectors Non-Metallic Minerals and Electrical Engineering: in these sectors a considerable negative energy efficiency improvement has been compensated by a decreasing weight in total Manufacturing value added. However, Chemicals shows the opposite with a considerable improvement in energy efficiency that has been insufficient to compensate for a substantial increase of its share in total Manufacturing value added. Hence, once we exclude Chemicals from our sample the sign of the structure effect reverses, measured over the period 1987–2005.[8] Finally, Table 5.3 underlines that within-sector energy efficiency improvements have been mainly realized after 1995.

To put these results in an international perspective, we provide in Figure 5.5 for the three different time periods the annualized growth rates of manufacturing energy intensity in the Netherlands as compared to other OECD countries, before and after correcting for the impact of changes in the composition of the manufacturing sector. The left side of Figure 5.5 provides annualized energy intensity growth rates before decomposition (gross) and the right side provides annualized energy intensity growth rates after correction for the impact of structural changes (net). From the Figure it can be seen that measured over the period 1987–2005 performance in the Netherlands in terms of decreasing Manufacturing energy intensity ranks below average within the OECD. More specifically, in this period gross manufacturing energy intensity in the Netherlands decreased on average per year with 0.23% (cf. Tables 5.1 and 5.2), which after correcting for the (negative) impact of structural shifts improves to a decrease of 0.54%. Regarding the period 1995–2005, Figure 5.5 shows that performance in terms of gross average annual energy intensity decrease in the Netherlands (with 1.28%) ranks again below the OECD average, but that after correcting for the (negative) impact of structural shifts, the decrease in net aggregate Manufacturing energy intensity ranks above OECD average with a decrease of 1.86% on average per year. In other words, during the period 1995–2005 energy efficiency improvements in the Dutch manufacturing were substantial in an international perspective, but they have been undone by shifts toward a more energy-intensive manufacturing structure – to such an extent that performance in gross manufacturing energy intensity decrease in the Netherlands belongs to the lower ranks within the OECD.

Our results compare relatively well the findings of SenterNovem (2006: 16), who reports a total energy-efficiency improvement of 19.1% between 1998 and 2005, equivalent to about 2.4% per year. According to their findings, 66% of the energy-efficiency improvements is caused by process efficiency, 13% is due to renewable energy use and 21% results from energy saving product development. For the period 1980–2003 Neelis et al. (2007)

[8] Exact figures for individual sectors in this case only differ from those in Table 5.3 in terms of magnitude and not in sign; hence, we not present them separately, also given considerations regarding the size of the paper. Details are available upon request.

report an estimated average annual primary energy efficiency improvement of 1.3% in the Dutch manufacturing sector, based on physical production indicators.

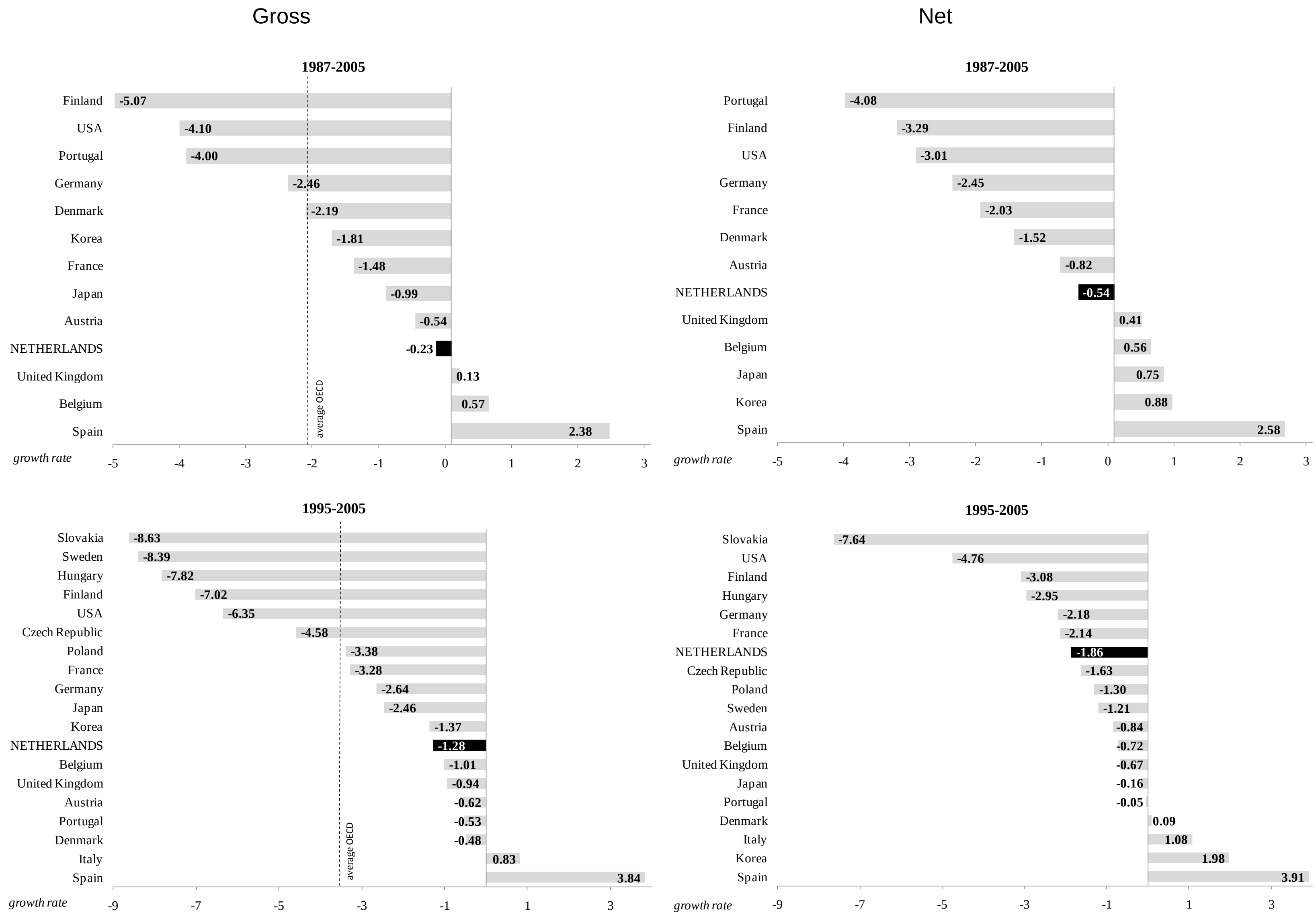


Figure 5.5 Average annual growth rate Manufacturing energy intensity before (gross) and after (net) correcting for structural changes

We continue by taking a closer at energy intensity *levels* in the various Dutch Manufacturing sectors, as compared to the OECD average in these sectors. The results are presented in Figure 5.6 for three years (1987, 1995 and 2005). Again, to facilitate interpretation, we present the results in terms of *energy productivity*, i.e. the inverse of energy intensity. A relative good performance of the Netherlands is then defined as a relatively high level of energy productivity, which corresponds to a relatively low level of energy intensity.

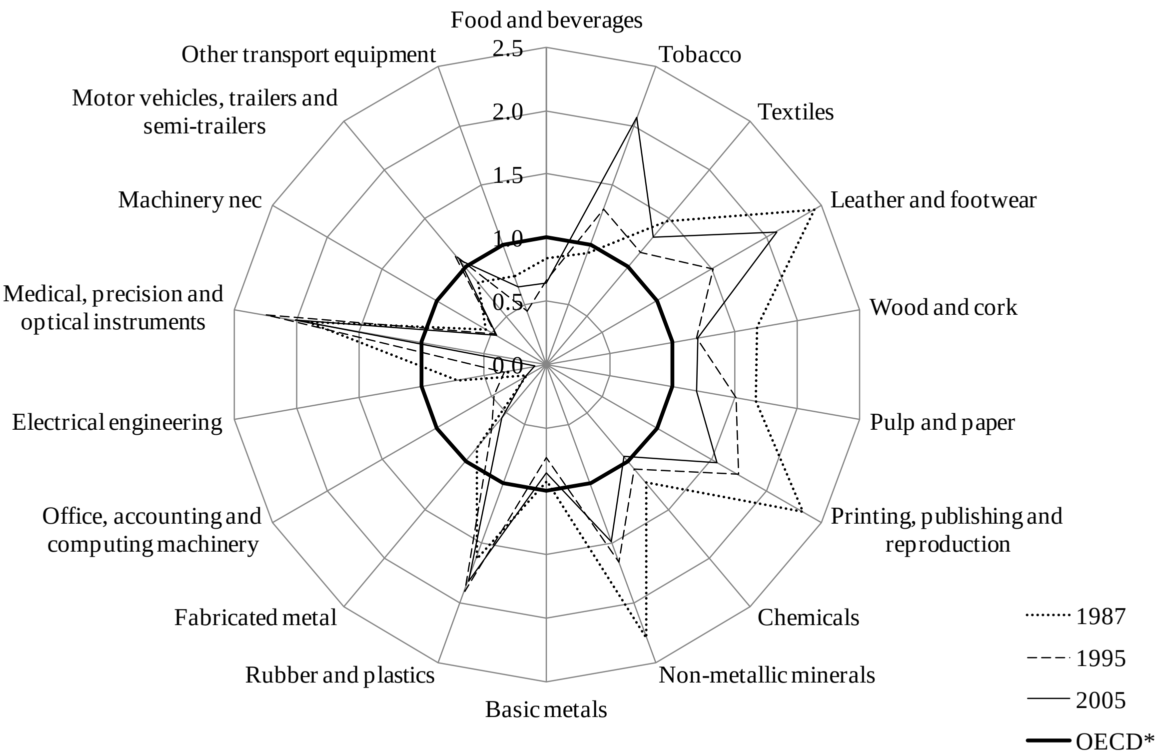


Figure 5.6 Energy productivity levels of manufacturing sectors in the Netherlands compared to OECD average

The Figure leads to a couple of observations. First, in the energy-intensive sectors Chemicals and Basic Metals as well as in the sector Motor vehicles etc. energy productivity performance of the Netherlands is close to the OECD average. Second, energy productivity levels in the Netherlands are (considerably) above the OECD average in the sectors Printing etc., Leather and Footwear, Tobacco, Medical and other Instruments, and Rubber and Plastics, and Non-Metallic Minerals. Third, over time the relative performance of the energy-intensive sectors Chemicals and especially Non-Metallic Minerals tends to decline. Finally, in Food and Beverages, Machinery not elsewhere classified, Electrical Engineering and Fabricated Metal energy productivity levels in the Netherlands are much below the OECD average, for all years included.

We conclude this section by taking a closer look at the sector dynamics in the Netherlands. To this aim we present in Figure 5.7 changes in the sector composition of the Dutch manufacturing sector between 1987 and 2005 (measured as value added shares) in relation to energy intensity levels of individual sectors.

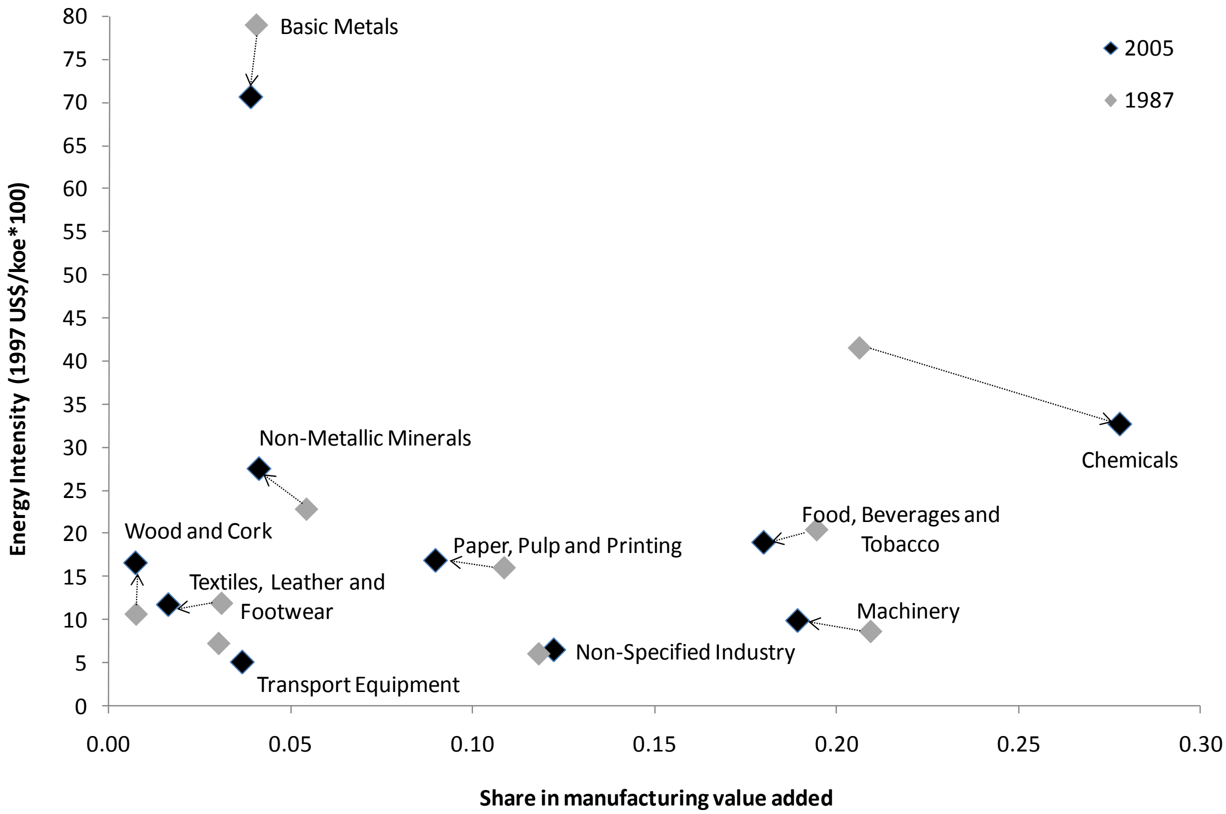


Figure 5.7 Evolution of the relation between the relative magnitude and the level of energy intensity in Dutch Manufacturing sectors.

From the Figure it can be seen that the Manufacturing sector in the Netherlands is characterized by a tendency to specialize in energy-intensive sectors. Also, the Figure shows that this pattern is predominantly driven by the Chemicals sector, which since 1987 further enhanced its dominant position (in terms of value added) in spite of a decreasing energy intensity level. As noted in Section 2, in the EU KLEMS data the Chemicals sector combines the energy-intensive sub-sector Basic Industrial Chemicals and the energy-extensive sub-sector Pharmaceuticals. While we do not have energy data for these sub sectors, the underlying value added data clearly indicate that growth in the Dutch Chemical sector since 1987 has almost exclusively been realized by the energy-intensive sub-sector Basic Industrial Chemicals.

6. Services

In this section we analyze the development of energy intensity in the Dutch Service sector, identifying the role of 23 Manufacturing sectors, consisting of 9 main sectors and 14 sub sectors. Similar to sections 4 and 5, we present in Figure 6.1 the shares of the 9 main Service sectors in aggregate Services energy consumption and aggregate value added, for the year 2005.

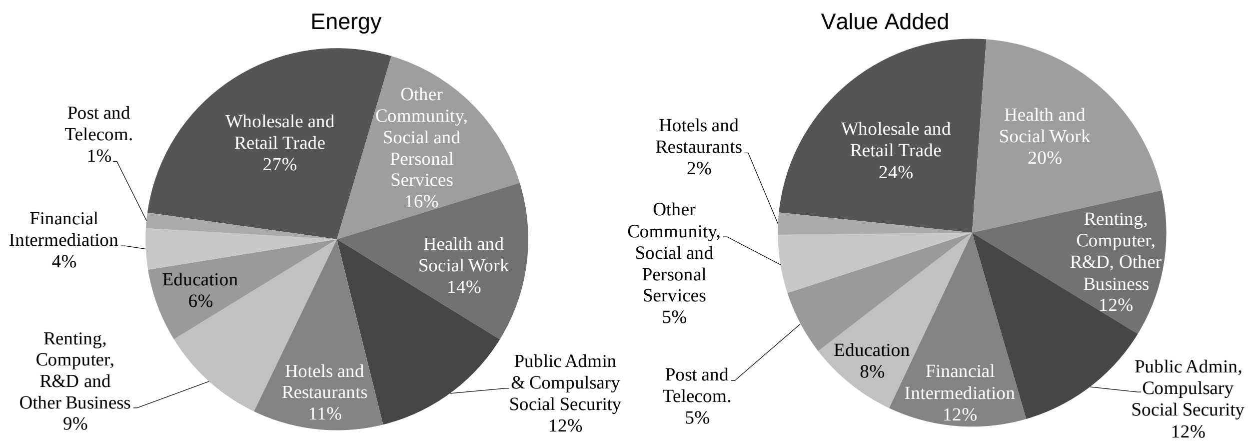


Figure 6.1. Percentage sub-sector shares of aggregate Services energy consumption and value added in the Netherlands, 2005.

From the Figure it can be seen that the sector Wholesale and Retail Trade plays a major role in the Dutch Service sector, accounting for 23% of Service sector energy use and 24% of Service sector value added. Other relatively large sectors include Health and Social Work, Public Administration and Renting etc. – both in terms of value added and energy use. With 12% Financial Intermediation is a large sector in terms of value added, but its share in energy consumption within Services is relatively small (4%). The opposite is true for Hotels and Restaurants, and Other Community, Social and Personal Services. The shares shown in Figure 6.1 have been fairly constant since 1987, except for increase shares of the sub-sector Wholesale and Retail Trade, Renting etc., and Post and Telecommunications– which all increased their value added share with a few percent points.

In Figure 6.2, we compare these shares with the average OECD shares. Recall that values are indexed, relative to the OECD average as denoted by the axes (OECD = 1.0). The Figure shows that, relative to the OECD average, the Netherlands specializes in the sectors Recreation etc., Education and (although increasingly less so) Research and Development. A comparison of the figures for 1987 and 2005 shows again the increasing relative importance of Other Wholesale and Commission Trade, Hotels and Restaurants, Computer and related activities, Financial Intermediation, and Public Administration. Especially Post and Telecommunications became considerably smaller relative to the OECD average.

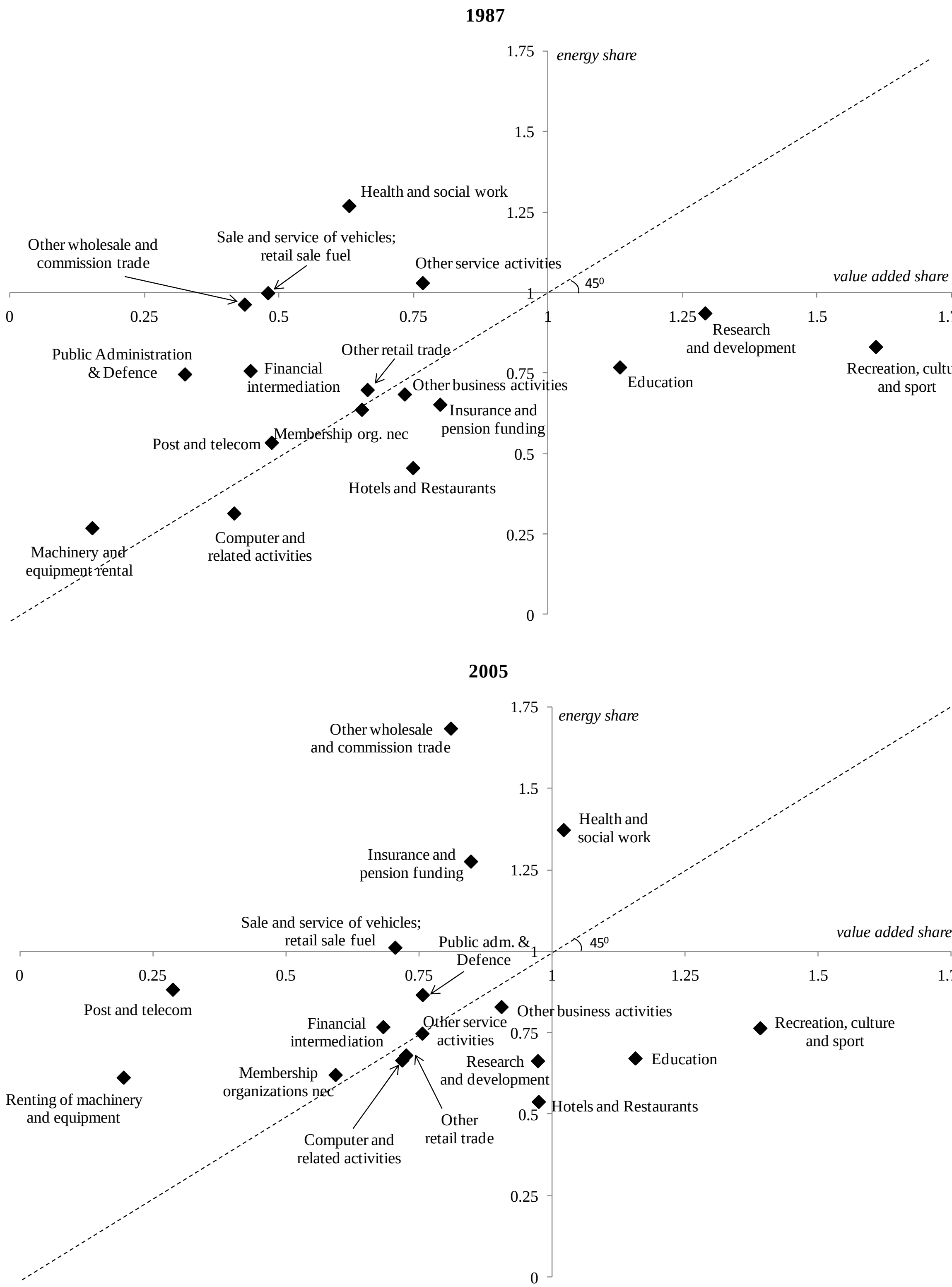


Figure 6.2 Share of Dutch Service sectors in total Services value added and energy use in 1987 and 2005, relative to OECD average (OECD =1.0).

Again, points on the dashed diagonal line are points where the sectoral energy intensity is the same as the aggregate OECD average. Sectors to the Northwest are relatively energy intensive, whereas sectors to the South East are energy extensive. The Figure shows that about half of the Service sectors in the Netherlands have a lower energy intensity level than the OECD average, especially Recreation etc., Education, Hotels and Restaurants, and Research and Development. Especially in the sectors Other Wholesale and Commission Trade, and Insurance and Pension Funding, energy intensity in the Netherlands is structurally above the OECD average.

To gain more insight in the development of energy intensity over time, we present in Table 6.1 for three different time periods the average annual growth rate of energy intensity and its components: energy use and value added. We do so for the aggregate economy level as well as individual main sectors. Unlike the Manufacturing sector, for the Service sector the IEA classification does not provide a sub-sector detail. Hence, we are not able to include by way of comparison IEA based data on energy use and energy intensity (for IEA data at the aggregate Service sector level we refer to Table 4.1). Table 6.1a shows that at the aggregate Services level, between 1987 and 2005, energy intensity in the Netherlands increased with an average 0.4% per year. The first column of the Table shows that this increase largely results from an increase in energy intensity in the subsectors Financial Intermediation and Public Administration. In contrast, energy intensity decreased particularly in Post and Telecommunications as well as Wholesale and Retail Trade. The second and third columns of Table 6.1a show that these trends have been irregular over time. Remarkably, between 1987 and 1995, aggregate Service sector energy intensity levels increased considerably (2.7% per year), which was driven by increasing energy intensity levels in virtually all sectors except Post and Telecommunications. After 1995, aggregate Service sector energy intensity fell considerably (with 1.4% per year), driven by developments in most Service sub-sectors, especially Wholesale and Retail Trade, Post and Telecommunications, Financial Intermediation, Renting etc., and Health and Social Work. A closer look at the underlying data in Table 6.1b shows that particularly in the sector Renting etc., both value added and energy use have increased considerably, especially between 1987 and 1995. The sharp decrease in the sector Post and Telecommunication results essentially from a decrease in energy use before 1995 and a sharp rise in value added in the period after 1995.

Table 6.1a Change in Services energy intensity

Average annual growth rate	Energy Intensity		
	1987−2005	1987−1995	1995−2005
SERVICES	0.4	2.7	–1.4
WHOLESALE AND RETAIL TRADE	–0.6	1.6	–2.3
Sale etc. of motor vehicles and motorcycles; retail sale of fuel	1.2	3.8	–0.9
Wholesale trade and commission trade, except motor vehicles etc.	–0.5	1.7	–2.3
Retail trade, except motor vehicles etc.; repair of household goods	0.1	2.3	–1.6
HOTELS AND RESTAURANTS	2.1	4.1	0.5
POST AND TELECOMMUNICATIONS	–6.3	–6.2	–6.3
FINANCIAL INTERMEDIATION	1.3	4.7	–1.4
Financial intermediation, except insurance and pension funding	1.2	5.0	–1.9
Insurance and pension funding, except compulsory social security	1.0	1.6	0.5
Activities related to financial intermediation	2.5	9.8	–3.3
RENTING, COMPUTER, R&D and OTHER BUSINESS	0.5	2.8	–1.4
Renting of machinery and equipment	0.4	1.6	–0.5
Computer and related activities	–2.0	–1.1	–2.8
Research and development	2.5	10.8	–4.1
Other business activities	1.0	2.3	0.0
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECURITY	3.8	7.1	1.1
EDUCATION	0.9	2.2	–0.1
HEALTH AND SOCIAL WORK	–0.2	2.5	–2.3
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	0.4	1.1	–0.1
Sewage and refuse disposal, sanitation and similar activities	–2.7	–4.8	–1.0
Activities of membership organizations n.e.c.	0.2	0.9	–0.4
Recreational, cultural and sporting activities	1.1	4.4	–1.6
Other service activities	2.5	2.7	2.3

Table 6.1b Change in Services energy use and value added

Average annual growth rate	Energy Use			Value Added		
	1987–2005	1987–1995	1995–2005	1987–2005	1987–1995	1995–2005
SERVICES	3.1	5.1	1.6	2.7	2.3	3.1
WHOLESALE AND RETAIL TRADE	3.2	5.0	1.7	3.8	3.4	4.0
Sale etc. of motor vehicles and motorcycles; retail sale of fuel	3.4	4.8	2.3	2.2	0.9	3.2
Wholesale trade and commission trade, except motor vehicles etc.	4.8	7.0	3.0	5.3	5.3	5.3
Retail trade, except motor vehicles etc.; repair of household goods	1.9	3.7	0.4	1.7	1.4	2.0
HOTELS AND RESTAURANTS	3.6	6.2	1.5	1.5	2.1	1.0
POST AND TELECOMMUNICATIONS	1.5	–3.2	5.2	7.7	3.0	11.5
FINANCIAL INTERMEDIATION	4.6	7.7	2.1	3.3	3.0	3.6
Financial intermediation, except insurance and pension funding	5.2	7.2	3.5	4.0	2.2	5.4
Insurance and pension funding, except compulsory social security	3.1	6.2	0.7	2.1	4.6	0.1
Activities related to financial intermediation	5.4	12.9	–0.6	2.8	3.0	2.7
RENTING, COMPUTER, R&D and OTHER BUSINESS	5.4	9.2	2.4	4.9	6.4	3.8
Renting of machinery and equipment	7.6	12.6	3.5	7.1	11.1	4.0
Computer and related activities	8.8	10.6	7.3	10.8	11.7	10.1
Research and development	4.0	11.9	–2.3	1.5	1.1	1.8
Other business activities	5.1	8.0	2.9	4.1	5.7	2.8
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECURITY	4.7	7.5	2.4	0.9	0.4	1.3
EDUCATION	0.7	1.4	0.1	–0.2	–0.8	0.2
HEALTH AND SOCIAL WORK	1.9	4.2	0.1	2.1	1.8	2.4
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	2.6	3.2	2.0	2.1	2.1	2.2
Sewage and refuse disposal, sanitation and similar activities	1.7	0.4	2.8	4.4	5.2	3.8
Activities of membership organizations n.e.c.	2.2	3.4	1.2	2.0	2.5	1.6
Recreational, cultural and sporting activities	3.5	5.8	1.7	2.4	1.4	3.2
Other service activities	2.7	3.7	1.9	0.2	1.0	–0.4

We continue our descriptive analysis by taking a closer look at the development of energy intensity *levels* over time. In Figure 6.3 we show this development (index: 1987=100) for 23 Dutch Service sectors, including 9 sub-sectors and 14 main sectors for which no sub-sector detail is available (cf. Table 6.1). Figure 6.1 clearly shows that only in a few Service sectors energy intensity levels structurally decreased during the period under consideration. This is especially true in Post and Telecommunications, Computer and related activities, and Other Services; those sectors are characterized by a considerable structural decrease in energy intensity. In virtually all other Service sectors energy intensity tend to gradually increase over time, although after 1995 this trend is weaker and in some sectors reversed. Especially in the sectors Public Administration and Defense, Hotels and Restaurants, and Research and Development energy intensity has increased over time. Finally, in the sub sector Other Business Activities energy intensity fluctuates sharply over time.

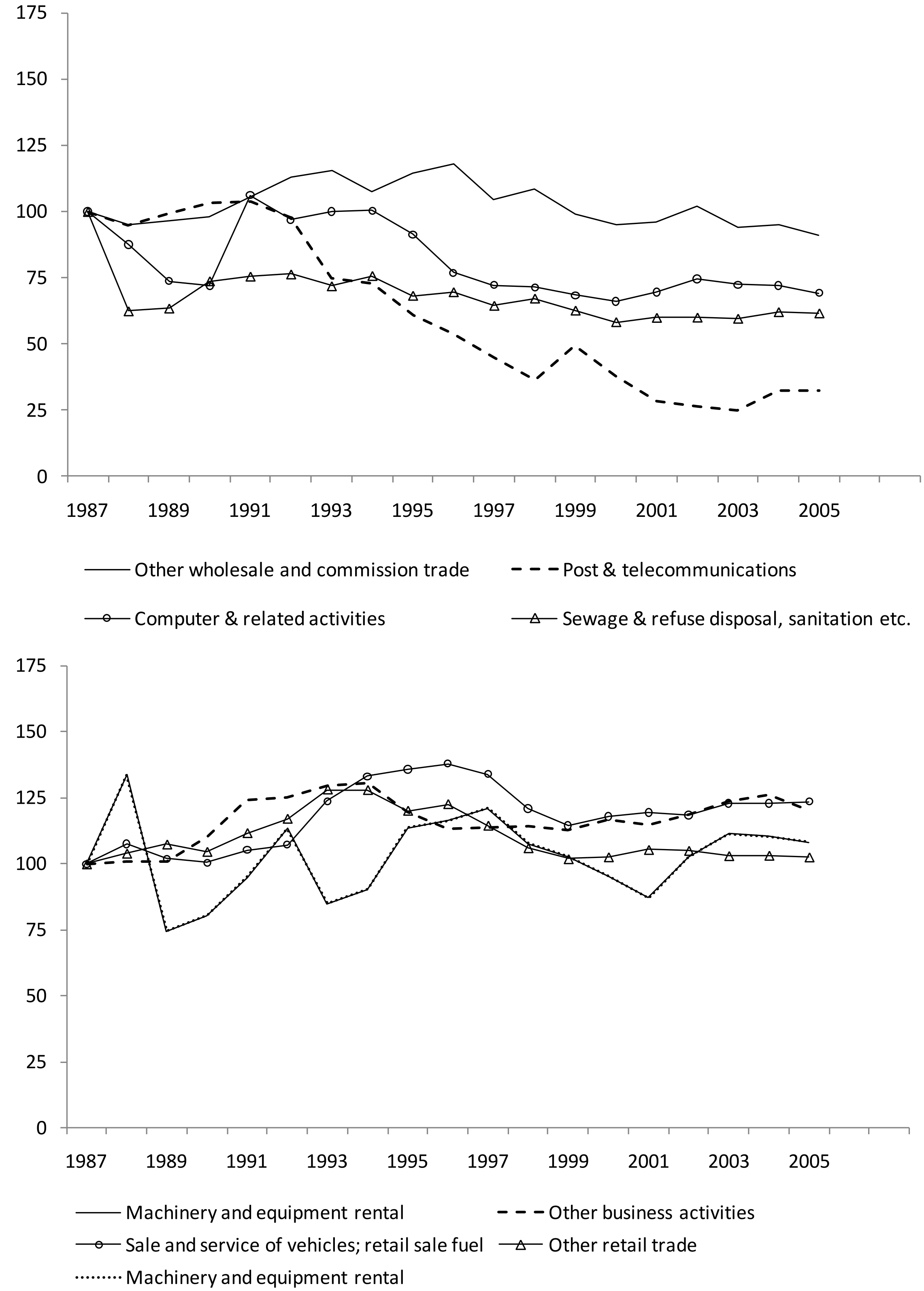


Figure 6.3a, b. Development energy intensity by Services sector (index, 1980=100)

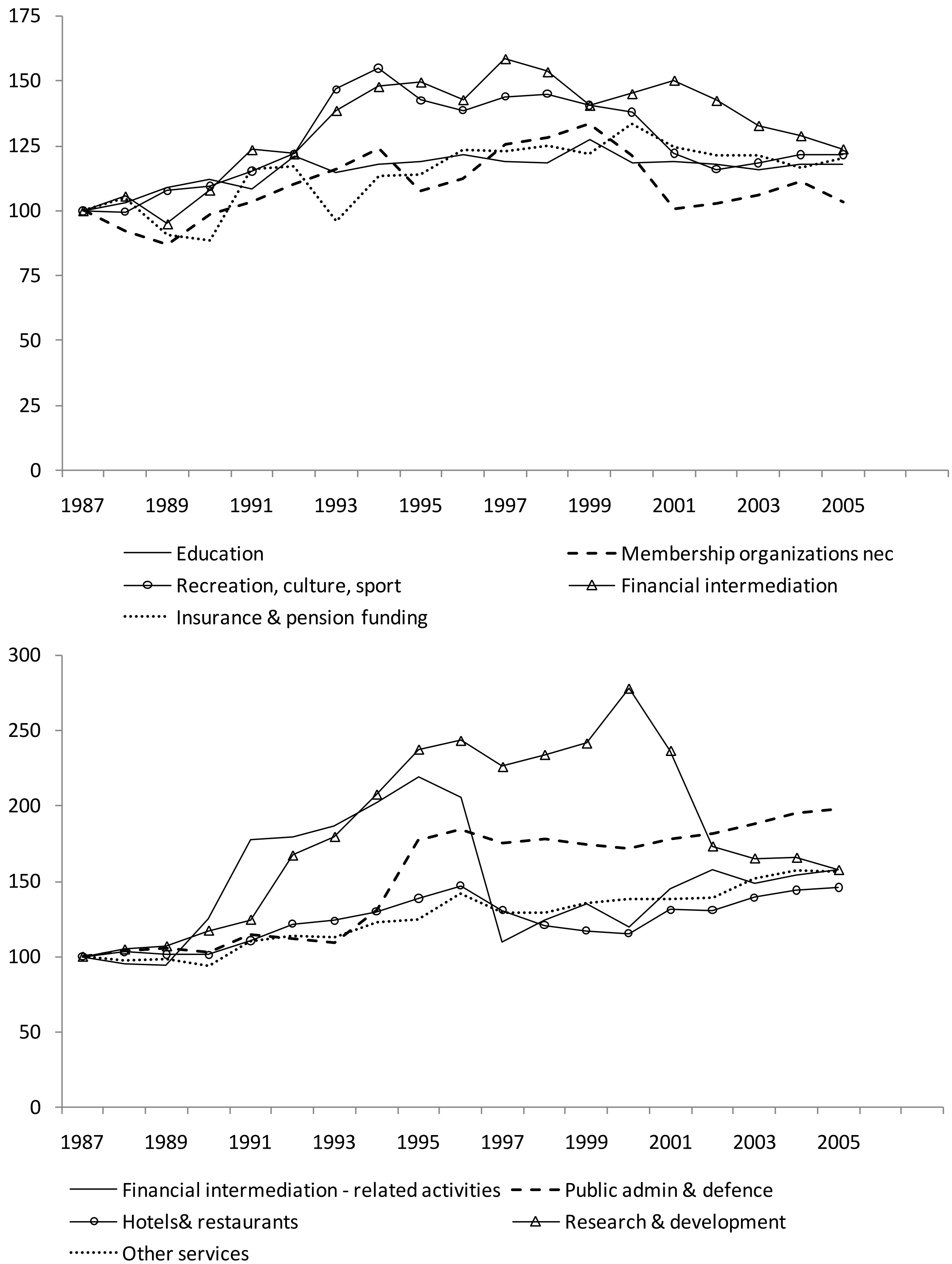


Figure 6.3c, d. Development energy intensity by Services sector (index, 1980=100)

Table 6.2 Average annual growth rates energy intensity by Services sub sector.

Average annual growth rates	1987−2005		1987−1995		1995−2005			
	NLD	OECD	NLD	OECD	NLD	OECD	EU-12	EU-4
SERVICES	0.4	–1.3	2.7	–1.2	–1.4	–1.5	–0.8	–2.4
WHOLESALE AND RETAIL TRADE	–0.6	–1.7	1.6	–1.6	–2.3	–1.7	–1.0	–5.3
Sale etc. of motor vehicles and motorcycles; retail sale of fuel	1.2	–1.8	3.8	–1.2	–0.9	–2.2	0.3	1.0
Wholesale trade and commission trade, except motor vehicles etc.	–0.5	–1.8	1.7	–2.1	–2.3	–1.6	–2.6	–8.2
Retail trade, except motor vehicles etc.; repair of household goods	0.1	–1.4	2.3	–0.7	–1.6	–2.0	0.6	–4.6
HOTELS AND RESTAURANTS	2.1	0.6	4.1	0.7	0.5	0.5	0.1	–2.1
POST AND TELECOMMUNICATIONS	–6.3	–1.4	–6.2	–2.2	–6.3	–0.9	–3.3	–9.7
FINANCIAL INTERMEDIATION	1.3	–0.9	4.7	0.1	–1.4	–1.6	–0.6	0.4
Financial intermediation, except insurance and pension funding	1.2	–1.7	5.0	–0.9	–1.9	–1.9	–2.3	–3.5
Insurance and pension funding, except compulsory social security	1.0	3.0	1.6	4.3	0.5	2.4	5.3	10.1
Activities related to financial intermediation	2.5	–2.0	9.8	–2.7	–3.3	1.2	0.2	–11.7
RENTING, COMPUTER, R&D and OTHER BUSINESS	0.5	–0.4	2.8	–0.7	–1.4	–0.2	–1.1	–6.8
Renting of machinery and equipment	0.4	3.4	1.6	7.4	–0.5	0.0	–0.8	–1.5
Computer and related activities	–2.0	–1.7	–1.1	–0.9	–2.8	–2.4	–3.0	–2.8
Research and development	2.5	1.4	10.8	–0.1	–4.1	1.7	–0.6	0.5
Other business activities	1.0	0.1	2.3	0.2	0.0	0.1	–0.7	–7.8
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECURITY	3.8	–1.0	7.1	0.6	1.1	–2.3	1.0	–0.3
EDUCATION	0.9	–0.9	2.2	–0.2	–0.1	–1.5	1.4	2.5
HEALTH AND SOCIAL WORK	–0.2	–3.4	2.5	–5.2	–2.3	–1.9	–2.2	0.5
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	0.4	0.0	1.1	0.3	–0.1	–0.3	–0.1	2.3
Sewage and refuse disposal, sanitation and similar activities	–2.7	0.5	–4.8	1.3	–1.0	1.2	2.4	3.3
Activities of membership organizations n.e.c.	0.2	–0.1	0.9	–0.2	–0.4	0.1	0.2	–1.4
Recreational, cultural and sporting activities	1.1	1.0	4.4	2.6	–1.6	–0.1	–0.7	–0.1
Other service activities	2.5	0.7	2.7	1.4	2.3	0.2	–0.9	2.4

To put these trends in an international perspective, we provide in Table 6.2 the annualized growth rates of energy intensity in the Netherlands, in comparison with the OECD average. The Table shows that at the aggregate Service sector level performance is substantially below the OECD average, except for the period 1995–2005 when the rate of decrease in energy intensity very much resembles the OECD average and is above the EU-12 average. If we compare energy productivity growth in individual Dutch service sectors with the OECD average, we can see that in the Netherlands the decrease in energy intensity was particularly above average in the sectors Post and Telecommunications, Renting of machinery and equipment, Computer and related activities and Sewage and refuse disposal, sanitation and similar activities. After 1995 this also holds for Activities related to financial intermediation, Research and Development, and Recreational, cultural and sporting activities. In contrast, energy intensity performance in the Dutch Service sector was especially lower than the OECD average in the sectors Hotels and Restaurants, Activities related to financial intermediation (1987–1995), Public Administration and Other service activities. The same holds for performance after 1995 as compared with the EU-12 average, except for Public Administration – where performance in the Netherlands is very close to the EU-12 average.

Also at the aggregate Services level, changes in energy intensity result not only from technology-driven efficiency improvements in individual Services sectors (efficiency effect), but also from changes in composition of the Services sector in terms of the mix of sub sectors (structure effect). Again, we use index number decomposition (or shift-share) analysis to decompose changes in aggregate Services energy intensity into this structure and efficiency effect. In Figure 5.4 we present the results of our decomposition analysis for the Dutch Service sector by plotting the indexed evolution of aggregate energy intensity (Dtot) and the relative importance of the efficiency effect (Deff) and structure effect (Dstr).

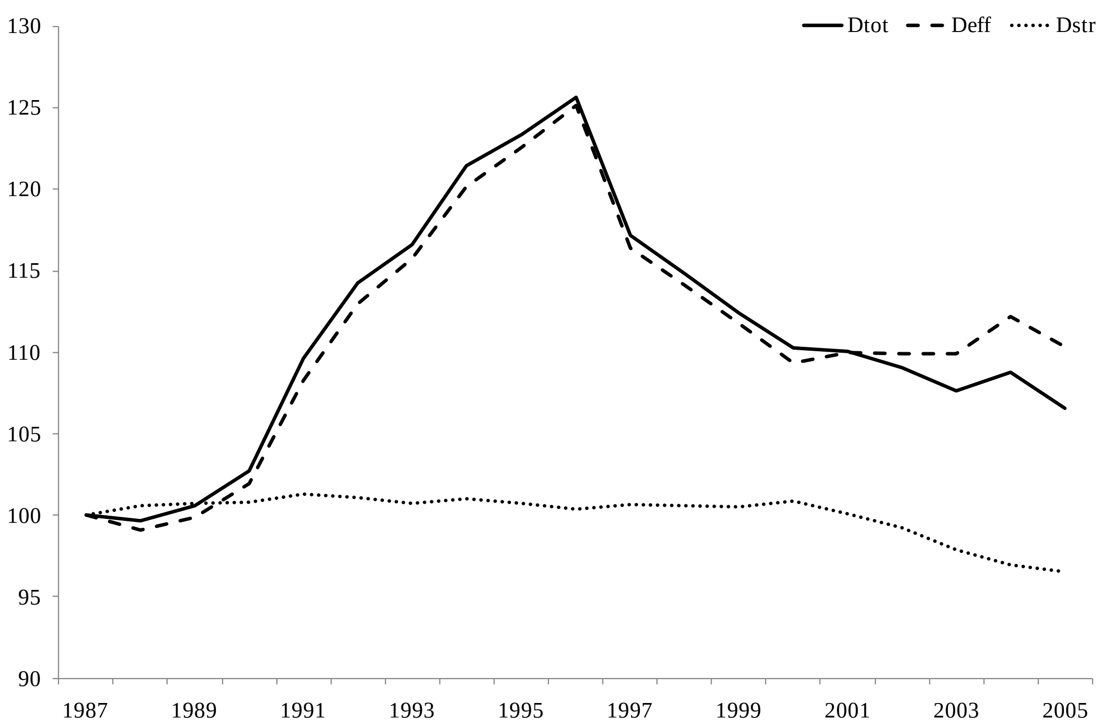


Figure 6.4 Decomposition of Services energy intensity development (Dtot) into a structure effect (Dstr) and efficiency effect (Deff); (index, 1987=100)

From Figure 6.4 it can be seen that since 1987 for most of the time changes in aggregate Services energy intensity are predominantly influenced by within-sector efficiency developments. Between 1990 and 2000, both the increase and subsequent decrease of Services energy intensity are primarily driven by an efficiency effect. During the same period, structural changes played only a minor role, in the form of slightly enhancing Service sector energy intensity. Since 2000, however, structural changes have started to play a more prominent and different role. More specifically, since 2000 changes in the industry product mix have contributed to a lower level of aggregate energy intensity in the Service sector – contrary to the period before 2000.

In order to examine the role of individual sectors in driving these results, we identify for each individual Service sector the percentage contribution of the total efficiency effect and the total structural effect to the growth rate of energy intensity at the aggregate Services level. The results are presented in Table 6.3, again for the three different time periods. The bottom line of Table 6.3 confirms that aggregate energy intensity increased when measured over the whole period 1987–2005, but has decreased since 1995. It also shows that changes in aggregate Service sector energy intensity are predominantly influenced by changes in within-sector efficiency levels but that structural changes have played an important role after 1995. More specifically, between 1987 and 2005 about one-third of the negative efficiency improvements were undone by shifts towards a less energy-intensive sector structure; between 1995 and 2005 structural changes explain about 30% of the decrease in energy intensity. In contrast, between 1987 and 1995 the contribution of structural changes is virtually zero.

The sectoral breakdown in Table 6.3 shows that the overall increase in aggregate energy intensity between 1987 and 2005 is mainly driven by developments in Wholesale and Commission Trade, Hotels and Restaurants, Other Business Activities and Public Administration. The contribution of Wholesale and Commission Trade is mainly caused by a structural effect, while Hotels and Restaurants as well as Public Administration contribute through a negative efficiency effect. In Other Business Activities structural changes and energy efficiency improvements reinforce each other in their contribution to an increasing aggregate Service sector energy intensity level. In addition, the Table shows that in contrast several other sectors contribute to decreasing aggregate Service sector energy intensity level, most notably the sub sectors Retail Trade, Education, Health and Social Work, and Sewage and Refuse Disposal. Except for Sewage and Refuse disposal, these contributions result mainly from structural changes. Moreover, from Table 6.3 it can be seen that in the sector Post and Telecommunication a considerable energy efficiency improvement has been compensated by an increasing weight in total Service sector value added. After 1995, the total efficiency effect is mainly driven by energy efficiency improvements in Wholesale trade and Commission trade, Retail Trade, and Health and Social Work.

Table 6.3 Average percentage contribution of the efficiency effect and the structural effect by Services sub sector to the average annual growth rate of energy intensity in the Dutch services sector.

	1987–2005			1987–1995			1995–2005		
	Efficiency Effect	Structure Effect	Total Effect	Efficiency Effect	Structure Effect	Total Effect	Efficiency Effect	Structure Effect	Total Effect
Sale etc. of motor vehicles and motorcycles; retail sale of fuel	12.9	–5.3	7.6	6.2	–2.1	4.1	–3.0	0.6	–2.4
Wholesale trade and commission trade, except motor vehicles etc.	–13.0	66.3	53.3	6.3	11.1	17.3	–18.5	18.3	–0.3
Retail trade, except motor vehicles etc.; repair of household goods	4.4	–30.9	–26.4	11.7	–4.3	7.3	–13.8	–9.6	–23.4
Hotels and restaurants	49.1	–27.8	21.3	14.9	–0.5	14.4	3.6	–14.8	–11.2
Post and telecommunications	–21.2	17.0	–4.2	–2.7	0.3	–2.4	–4.5	6.0	1.5
Financial intermediation, except insurance and pension funding	5.5	5.9	11.4	3.2	0.0	3.2	–2.8	3.5	0.7
Insurance and pension funding, except compulsory social security	2.1	–1.2	0.9	0.5	0.8	1.3	0.3	–1.8	–1.5
Activities related to financial intermediation	2.4	0.1	2.6	1.6	0.1	1.8	–1.3	–0.1	–1.4
Renting of machinery and equipment	0.3	3.3	3.6	0.2	0.9	1.1	–0.1	0.3	0.1
Computer and related activities	–3.6	14.1	10.5	–0.2	1.9	1.6	–1.7	4.3	2.6
Research and development	7.4	–3.5	3.9	6.1	–0.6	5.5	–4.7	–1.4	–6.2
Other business activities	13.7	18.7	32.4	4.3	6.7	11.0	0.2	–1.0	–0.9
Public admin and defence; compulsory social security	90.6	–42.6	47.9	25.1	–6.5	18.7	8.8	–13.6	–4.8
Education	15.9	–50.5	–34.6	6.2	–8.6	–2.4	–0.3	–12.6	–12.9
Health and social work	–5.8	–19.5	–25.3	13.7	–2.7	11.1	–22.0	–6.3	–28.3
Sewage and refuse disposal, sanitation and similar activities	–43.3	27.5	–15.8	–11.1	6.8	–4.3	–4.0	2.9	–1.1
Activities of membership organizations n.e.c.	0.8	–3.0	–2.2	0.6	0.2	0.8	–0.5	–1.7	–2.2
Recreational, cultural and sporting activities	17.4	–4.5	13.0	10.9	–2.1	8.8	–7.7	0.8	–6.9
Other service activities	11.8	–11.7	0.1	1.9	–0.9	1.1	3.1	–4.6	–1.5
SERVICES	147.5	–47.5	100.0	99.6	0.4	100.0	–69.1	–30.9	–100.0

To put these results in an international perspective, we provide in Figure 6.5 for the three different time periods the annualized growth rates of Service sector energy intensity in the Netherlands as compared to other OECD countries, before and after correcting for the impact of changes in the composition of the Service sector. The left side of Figure 5.5 provides annualized energy intensity growth rates before decomposition (gross) and the right side provides annualized energy intensity growth rates after correction for the impact of structural changes (net). From the figure it can be seen that measured over the period 1987–2005, gross energy intensity growth in the Netherlands rank more or less on average with 0.42% per year. However, after correcting for the (positive) impact of structural shifts this deteriorates to 0.62% per year, which is substantially below the OECD average. Regarding the period 1995–2005, Figure 6.5 shows that the decrease of gross average annual energy intensity with –1.43% is just above OECD; after correcting for the (negative) impact of structural shifts, performance is more or less at the OECD average with –1.03% per year.

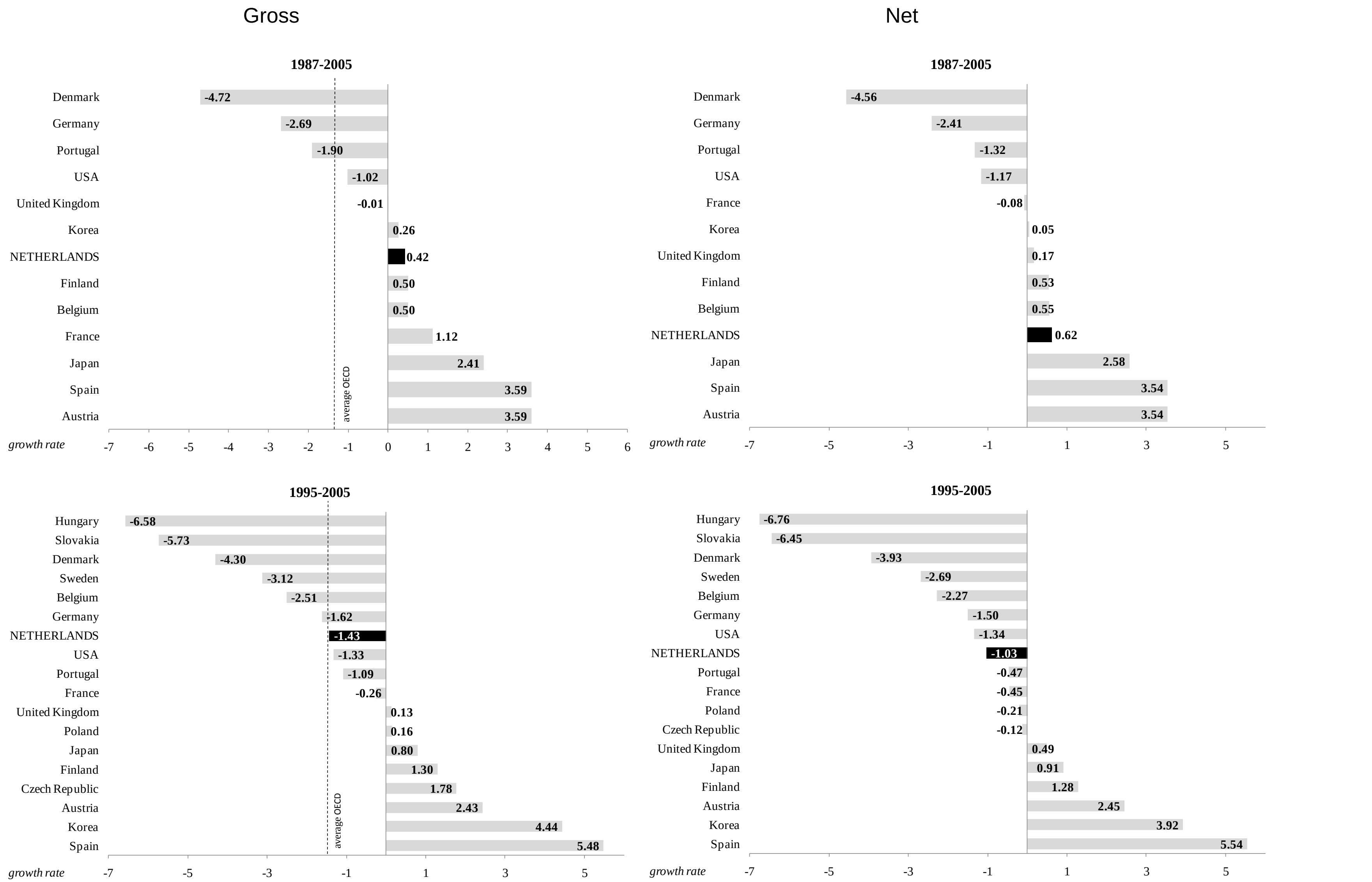


Figure 6.5 Average annual growth rate Service sector energy intensity before (gross) and after (net) correcting for structural changes

We continue by taking a closer look at energy intensity *levels* in the various Dutch Service sectors, as compared to the OECD average in these sectors. The results are presented in Figure 6.6 for three years (1987, 1995 and 2005). Again, to facilitate interpretation, we present the results in terms of *energy productivity*, i.e. the inverse of energy intensity. A relative good performance of the Netherlands is then defined as a relatively high level of energy productivity, which corresponds to a relatively low level of energy intensity.

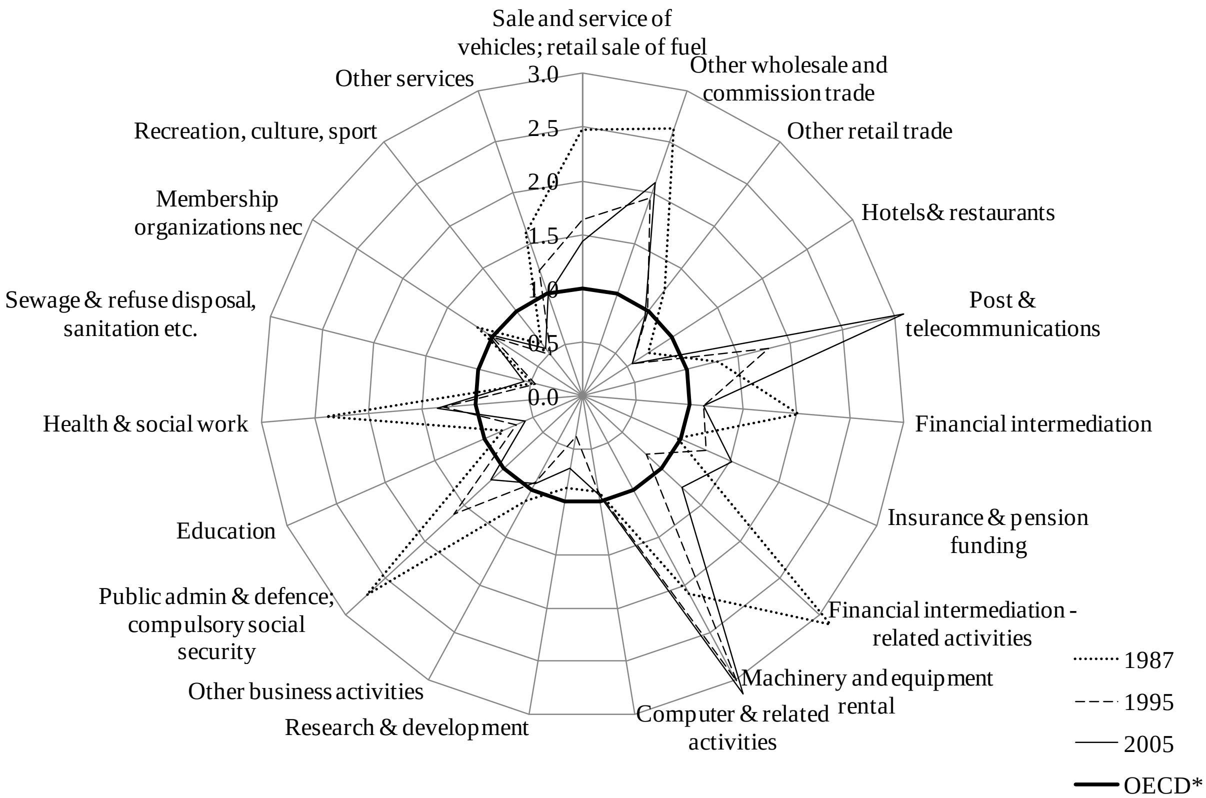


Figure 6.6 Energy productivity level of services sectors in the Netherlands relative to OECD average

The Figure leads to a couple of observations. First, energy productivity levels in the Netherlands are much above the OECD average in the sectors Machinery and Equipment rental, Post and Telecommunications, Wholesale and Commission Trade, and to a lesser extent also in Insurance and Pension Funding. Second, energy productivity levels in the Netherlands are (considerably) below the OECD average in the sectors Recreation etc., Sewage and Refusal Disposal, Education, Hotels and Restaurant, and to a lesser extent also in Research & Development.

We conclude this section by taking a closer look at the sector dynamics in the Netherlands. To this aim we present in Figure 6.7 changes in the sector composition of the Dutch Service sector in relation between 1987 and 2005 (measured as value added shares) to energy intensity levels of individual sectors. The Figure illustrates the considerable increase in energy intensity in the sector Hotels and Restaurants, the increasing role of Post and

Telecommunication and Wholesale and Retail Trade and the more or less constant energy intensity level in most other sectors.

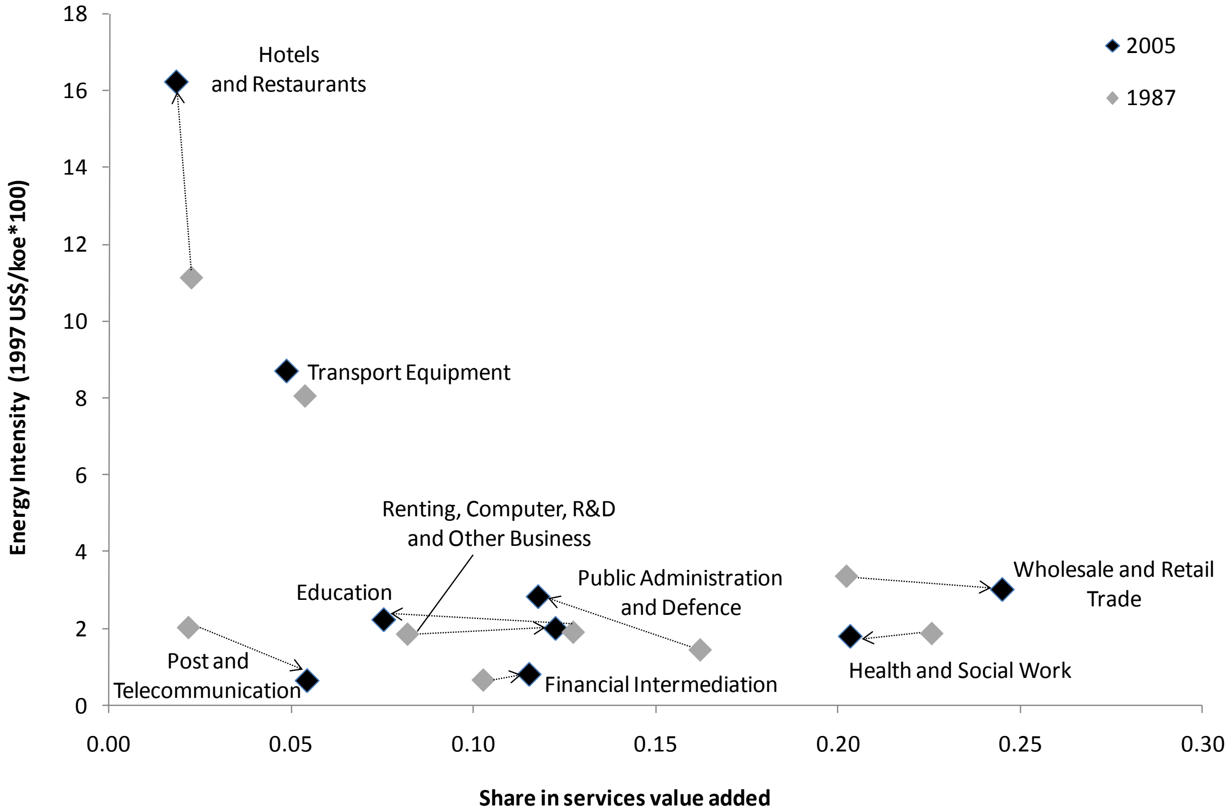


Figure 6.7 Evolution of the relation between the relative magnitude and the level of energy intensity in Dutch Service sectors.

7. Conclusions

This paper makes use of a new dataset to investigate energy intensity developments in the Netherlands over the period 1987–2005, in comparison with 18 other OECD countries. The heart of the dataset is formed by the recently developed 'EU KLEMS Growth and Productivity Accounts' database. This database includes information on both output and indexed volumes of energy input derived from a consistent framework of national accounts and supply-and-use tables and processed according to agreed procedures. Subsequently, we have linked the indexed volumes of energy input to physical energy consumption data from the International Energy Agency (IEA). As a result, and in contrast to most empirical studies in the field of energy economics, we are able to combine a cross-country perspective with a high level of sector detail, covering 25 Manufacturing sectors (10 main sectors, 15 sub sectors), 23 Service sectors (9 main sectors, 14 sub sectors), as well as the sectors Transport, Agriculture and Construction. Particularly innovative is our evaluation of energy intensity developments in a wide range of Service sectors.

Key limitations of our database include relatively aggregated sector definitions of the Chemical and Basic Metals Industries and an imprecise definition of energy intensity in the transport sector. Hence, results presented for these sectors have to be interpreted with caution. When comparing our results with energy intensity developments that are derived from the widely used IEA-STAN data, it is to be recognized that these data differ as regards the construction of both value added series and energy consumption series, with each database resting on different assumptions. Important advantages of our dataset are that value added and energy expenditures are mutually consistent and that the construction of value added series makes use of industry-specific PPPs. The link between EU KLEMS and IEA data, which enables cross-country comparison of energy intensity levels, rests on the assumption that in 2005 within a specific industry average energy prices are identical across sub-sectors. This would require the same fuel price levels as well as the same fuel mix across sub sectors within an industry – a requirement that is met in most sectors, except for the aggregate sector Non-Specified Industry. In contrast to the IEA-STAN dataset, our dataset does not allow to account for the role of fuel input mix in driving aggregate energy intensity developments.

We found that between 1987 and 2005 energy intensity in the Netherlands decreased on average with 0.9% points per year at the aggregate economy level and with 0.2% points at the aggregate Manufacturing sector level, whereas it increased with 0.4% points at the aggregate Service sector level. The energy-intensive Chemical sector plays a major role in Dutch Manufacturing, in 2005 accounting for 43% of Manufacturing energy use and 28% of Manufacturing value added. Once we exclude the Chemical sector, the average annual decrease in Manufacturing energy intensity between 1987 and 2005 reduces from 0.2% points to 0.1% points. These aggregate results are predominantly determined by within-sub sector energy intensity changes. At the same time, structural changes (i.e. changes in the sectoral composition of the economy) play an important role. In the Manufacturing sector, between 1987 and 2005 about half of the within-sub sector energy intensity reductions (in total about 0.5% points per year) were undone by a shift towards a more energy-intensive industry structure; between 1995 and 2005 this percentage is about one-third. In the Service sector, on the contrary, structural changes helped in decreasing energy intensity: between 1987 and 2005 about one-third of the increase in within-sub sector energy intensity (in total about 0.6%

points per year) was undone by a shift towards a less energy-intensive sector structure; between 1995 and 2005 structural changes explain about 30% of the decrease in energy intensity.

Considering these results from an international perspective, we found that energy intensity *growth rates* in the Netherlands are in general below the OECD average, with the Netherlands performing especially poor during the period 1987–1995. More specifically, at the aggregate economy level the reduction in energy intensity in the Netherlands equals the OECD average – averaging out a considerably poorer performance than the OECD before 1995 and a somewhat better performance after 1995. However, if we exclude the Transport and Construction sector the annualized energy intensity growth rate in the Netherlands between 1987 and 2005 is substantially below the OECD average in all periods. In the Manufacturing sector energy efficiency performance is below the OECD average when measured over the entire period 1987–2005. This is true for most Manufacturing sub sectors, especially during the period 1987–1995, whereas after 1995 performance in various Dutch Manufacturing sub sectors is above OECD average. At the aggregate Service sector level performance is also substantially below the OECD average, except for the period 1995–2005 when the rate of decrease in energy intensity very much resembles the OECD average.

In terms of energy intensity *levels*, performance of the Netherlands is very close to the OECD average at the aggregate economy level. The same is true for Manufacturing, although energy intensity levels tend to become higher than the OECD average. In Services, the energy intensity level in the Netherlands was about 50% lower than the OECD average in 1987, but this lead has almost disappeared by 2005. A similar development has occurred in the Construction sector. In Transport energy intensity levels in the Netherlands are much below the OECD average, but this result is somewhat difficult to interpret of data definitions. On the contrary, in Agriculture, energy intensity levels in the Netherlands are considerably higher than the OECD average, for all years included. This is due to the important role of energy intensive horticulture in the Dutch Agricultural sector.

A closer look at the sector dynamics in the Netherlands revealed that the Manufacturing sector in the Netherlands is characterized by a tendency to specialize in energy-intensive sectors. This pattern is predominantly driven by the Chemicals sector, which since 1987 further enhanced its dominant position. Underlying data indicate that growth in the Dutch Chemical sector has largely been realized by the energy-intensive sub-sector Basic Industrial Chemicals. Dynamics within the Dutch Service sector are principally characterized by an increasing role of Post and Telecommunication as well as Wholesale and Retail Trade, a considerable increase in energy intensity in the sector Hotels and Restaurants and a more or less constant energy intensity level in most other Service sectors.

References

Ang, B.W. (2004). ‘Decomposition for Policymaking in Energy: Which is the Preferred Method?’, *Energy Policy*, 32, pp. 1131−1139.

Ang, B.W. and F.Q. Zhang (2000). ‘A Survey of Index Decomposition Analysis in Energy and Environmental Studies’, *Energy*, 25, pp. 1149−1176.

Ark, B. van (1996). ‘Sectoral Growth Accounting and Structural Change in Post-War Europe’, in: B. van Ark and N. Crafts (eds), *Quantitative Aspects of Post-War European Economic Growth*, Cambridge: Cambridge University Press, pp. 84–164.

Boonekamp, P.G.M. (2009). *Monitoring Energieverbruik 1982–1996*, Petten: ECN–C–98–046.

Boonekamp, P.G.M., R. Harmsen, A. Kets and M. Menkveld (2002). *Besparingstrends 1990–2000; Besparing, instrumenten en effectiviteit*, Petten: ECN–C–02–015.

Berndt, E.R. (1978). ‘Aggregate Energy, Efficiency, and Productivity Measurement’, *Annual Review of Energy*, 3, pp. 225–273.

Boer, P. de (2009). ‘Generalized Fisher index or Siegel-Shapley Decomposition’, *Energy Economics*, 31, pp. 810−814.

Boyd, G.A. and J.M. Roop (2004). ‘A Note on the Fisher Ideal Index Decomposition for Structural Change in Energy Intensity’, *Energy Journal*, 25, pp. 87–101.

Buck, A. de, M. Blom, M. Smit and L. Wielders (2010). *Convenant Benchmarking Energie-efficiency: resultaten en vrijstellingen energiebelasting*, Delft: CE Delft.

Cleveland C.J., R.K. Kaufmann and D.I. Stern (2000). ‘Aggregation and the Role of Energy in the Economy’, *Ecological Economics*, 32, pp. 301–318.

Dollar, D. and E.N. Wolff (1993). *Competitiveness, Convergence, and International Specialization*, Cambridge MA: MIT Press.

Fagerberg, J. (2000). ‘Technological Progress, Structural Change and Productivity Growth’, *Structural Change and Economic Dynamics*, 11, pp. 393–411.

Farla, J.C.M. and K. Blok (2000). ‘The Use of Physical Indicators for the Monitoring of Energy Intensity Developments in the Netherlands, 1980–1995’, *Energy*, 25, pp. 609–638.

Farla, J.C.M. and K. Blok (2002). ‘Industrial Long-term Agreements on Energy Efficiency in The Netherlands. A Critical Assessment of the Monitoring Methodologies and Quantitative Results’, *Journal of Cleaner Production*, 10, pp. 165–182.

Fisher, I. (1922). *The Making of Index Numbers*, Boston: Houghton Mifflin.

Fisher-Vanden, K., G.H. Jefferson, H.M. Liu and Q. Tao (2004). ‘What’s Driving China’s Decline in Energy Intensity?’, *Resource and Energy Economics*, 26, pp. 77−97.

Florax, R.J.G.M., H.L.F. de Groot and P. Mulder (2011). *Improving Energy Efficiency through Technology: Trends, Investment Behaviour and Policy Design*, Cheltenham: Edward Elgar, forthcoming.

Gerdes, J. and P.G.M. Boonekamp (2009). *Energiebesparing in Nederland 1995–2007*, Petten: ECN–E–09–040.

Huntington, H.G. (2010). ‘Structural Change and U.S. Energy Use: Recent Patterns’, *Energy Journal*, 31, pp. 25–39.

International Energy Agency (2004). *Oil Crises and Climate Challenges – 30 Years of Energy Use in IEA Countries*, Paris: OECD.

Liu, N. and B.W. Ang (2007). 'Factors Shaping Aggregate Energy Intensity Trend for Industry: Energy Intensity versus Product Mix', *Energy Economics*, 29, pp. 609−635.

Maddison, A. (1952). 'Productivity in an Expanding Economy', *Economic Journal*, 62, pp. 584–594.

Mairet, N. and F. Decellas (2009). 'Determinants of Energy Demand in the French Service Sector: A Decomposition Analysis', *Energy Policy*, 37, pp. 2733−2744.

Massell, B.F. (1961). 'A Disaggregated View of Technical Change', *Journal of Political Economy*, 69, pp. 547–557.

Miketa, A. and P. Mulder (2005). 'Energy-Productivity Across Developed and Developing Countries in 10 Manufacturing Sectors: Patterns of Growth and Convergence', *Energy Economics*, 27, pp. 429−453.

Mulder, P. and H.L.F. de Groot (2003). *International Comparisons of Sectoral Energy- and Labour-Productivity Performance: Stylised Facts and Decomposition of Trends*, CPB Discussion Paper, no. 22, The Hague: CPB Netherlands Bureau for Economic Policy Analysis.

Mulder, P. and H.L.F. de Groot (2007). 'Sectoral Energy- and Labour Productivity Convergence', *Environmental and Resource Economics*, 36, pp. 85−112.

Mulder, P. and H.L.F. de Groot (2011). *Energy Intensity across Sectors and Countries: Empirical Evidence 1980–2005*, CPB Discussion Paper, no. 171, The Hague: CPB Netherlands Bureau for Economic Policy Analysis.

NEEDIS (1995). *Sectorstudie Landbouw en Visserij*, Report no. NDS–95–005, Petten: NEEDIS/ECN.

Neelis, M.K., C.A. Ramírez, M.K. Patel, J. Farla, P. Boonekamp and K. Blok (2007). 'Energy Efficiency Developments in the Dutch Energy-Intensive Manufacturing Industry, 1980–2003', *Energy Policy*, 35, pp. 6112−6131.

Nilsson, L. (1993). 'Energy Intensity in 31 Industrial and Developing Countries 1950−88', *Energy*, 18, pp. 309−322.

Nooij, M. de, R. van der Kruk and D.P. van Soest (2003). 'International Comparisons of Domestic Energy Consumption', *Energy Economics*, 25, pp. 359–73.

O'Mahony, M. and M.P. Timmer (2009). 'Output, Input and Productivity Measures at the Industrial Level: The EU KLEMS Database', *Economic Journal*, 119, pp. F347−F403.

Ramírez, C.A., M.K. Patel and K. Blok (2002). *An Analysis of the Dutch Service Sector: Energy Consumption and Trends*, Report no. NWS E–2002–47, Utrecht: Utrecht University, Department of Science, Technology and Society.

Ramírez, C.A., M.K. Patel and K. Blok (2005). 'The Non-Energy Intensive Manufacturing Sector. An Energy Analysis Relating to the Netherlands', *Energy*, 30, pp. 749−767.

Ramírez, C.A., M. Patel and K. Blok (2006). 'How Much Energy to Process One Pound of Meat? A Comparison of Energy Use and Physical Energy Intensity of Four European Countries', *Energy*, 31, pp. 1711−1727.

Ramírez, C.A., K. Blok, M. Neelis and M. Patel (2006). 'Adding Apples and Oranges: The Monitoring of Energy Efficiency in the Dutch Food Industry', *Energy Policy*, 34, pp. 1720−1735.

Schipper, L. and S. Meyers (1992). *Energy Efficiency and Human Activity: Past Trends and Future Prospects*, Cambridge: Cambridge University Press.

Schipper, L., F. Unander, S. Murtishaw and M. Ting (2001). 'Indicators of Energy Use and Carbon Emissions: Explaining the Energy Economy Link', *Annual Review of Energy and Environment*, 26, pp. 49–81.

SenterNovem (2006). *Meerjarenafspraken Energie-Efficiency; Resultaten 2005*, Report no. 3MJAF0635, Utrecht: SenterNovem.

Shapley, L.S. (1953). 'A Value for N-Person Games', in: Kuhn, H. and A.W. Tucker, *Contributions to the Theory of Games II*, Princeton, NJ: Princeton University Press, pp. 307–317.

Siegel, I.H. (1945). 'The Generalized "Ideal" Index-number Formula', *Journal of the American Statistical Association*, 40, pp. 520–523.

Van der Velden, N. and P. Smit (2008). *Energiemonitor van de Nederlandse Glastuinbouw*, Report no. 2009–092, The Hague: LEI Wageningen UR.

Worrell, E. (2004). 'Industrial Energy Use, Status and Trends', *Encyclopedia of Energy*, pp. 395–406.

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